



Compendium Of NASA Data Base For The Global Tropospheric Experiment's Transport And Atmospheric Chemistry Near the Equator - Atlantic (TRACE-A)

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COMPENDIUM OF NASA DATA BASE FOR THE
GLOBAL TROPOSPHERIC EXPERIMENT'S
TRANSPORT AND ATMOSPHERIC CHEMISTRY
NEAR THE EQUATOR - ATLANTIC
(TRACE-A)

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SUMMARY

The report provides a compendium of NASA aircraft data that are available from NASA's Global Tropospheric Experiment's (GTE) Transport and Atmospheric Chemistry near the Equator - Atlantic (TRACE-A) conducted in September and October 1992. The TRACE-A experiment afforded the scientific community with the first opportunity to study the atmospheric chemistry and meteorology over the tropical south Atlantic Ocean with emphasis on the impact of continental outflow from South America and Africa to this region. The study was prompted by satellite measurements in the late 1980s which showed a region of seasonally (austral spring or September/October) enhanced tropospheric ozone off the west coast of southern Africa. It was hypothesized that the ozone enhancement was the result of widespread vegetation burning in South America and Africa. TRACE-A flight experiments were conducted from intensive bases in Brazil, South Africa, Namibia, and the Ascension Island. The broad objectives of the TRACE-A experiments were to study chemical processes and long-range transport associated with South American and African continental outflow during periods of widespread vegetation burning, and to understand the ozone enhancements observed over the southern tropical Atlantic Ocean during the September/October time period.

TRACE-A was conducted in coordination with the Southern African Fire-Atmosphere Research Initiative (SAFARI). TRACE-A and SAFARI, coordinated through the International Global Atmospheric Chemistry (IGAC) Project, comprised the core of IGAC's 1992 STARE (South Tropical Atlantic Regional Experiment) initiative whose focus was the impact of biomass burning on the biosphere and atmosphere. TTACE-A included measurements aboard NASA's DC-8 aircraft spanning the South American and African continents and measurements aboard two Brazilian aircraft as well as extensive Brazilian surface station and rawinsonde/ozonesonde measurements within Brazil. SAFARI also included airborne measurements other than the NASA DC-8 and an extensive surface station network of measurements in southern Africa.

The format of this compendium utilizes data plots--time series and altitude profiles--of selective data acquired aboard the NASA/Ames DC-8 aircraft during TRACE-A. The purpose of this document is to provide a representation of aircraft data that are available in archived format via NASA Langley's Distributed Active Archive Center (DAAC). The data format is not intended to support original research/analyses, but to assist the reader in identifying data that are of interest. This compendium is for only the NASA aircraft data. The DAAC archived data bases include numerous supporting data including meteorological observations/products, results from surface studies, satellite observations, and data from sonde releases.

INTRODUCTION

The goal of the NASA Tropospheric Chemistry Program is to develop an understanding of the chemical cycles that control the composition of the troposphere and to assess the susceptibility of the global atmosphere to chemical change. A major component of the NASA program is the Global Tropospheric Experiment (GTE), which consists of a series of field experiments designed to (1) evaluate the capability of instrument techniques to measure, under field conditions, the minute concentrations of key chemical species in the troposphere; and (2) systematically address tropospheric chemistry issues relevant to global change, through airborne sampling expeditions, coupled with modeling and laboratory studies. GTE is primarily an aircraft-based program supplemented by ground-based measurements. Satellite data also play important roles. Space Shuttle observations of tropospheric carbon monoxide distributions have been used to plan and direct the course of expeditions, for example, over tropical rain forests and for continental outflow into the tropical Atlantic Ocean. Landsat land-surface images have facilitated the extrapolation of regional Arctic-tundra measurements into global-scale conclusions. Total Ozone Measurements from Satellites (TOMS) have helped place GTE observed ozone distributions/budgets into a global perspective (temporal and spatial) and to guide intensive aircraft studies over the tropical Atlantic Ocean. Weather data returned by environmental satellites have guided flight planning for research flights. The Distributed Active Archive Center (DAAC) data include many of the satellite, surface, and meteorological products used to support GTE missions or analyses.

The GTE airborne expeditions have focused on studies of the remote global atmosphere in order to provide well-documented baseline measurements of the unperturbed environment and to fully understand the chemical cycles underlying the natural environment. Table 1 and Figure 1 summarize GTE missions conducted through 1994. The GTE expeditions have been conducted in a diverse range of environments and with different scientific goals. The Chemical Instrument Test and Evaluation (CITE) series was designed to study

our ability to measure key tropospheric gaseous species by exposing selected instrumentation to a wide range of measurement conditions. The Atmospheric Boundary Layer Experiments (ABLE) were designed to study the emission, chemical processes, and dynamics of the boundary layer, and have been conducted over ecosystems known to have significant influence on the global troposphere. The importance of long-range transport of natural and anthropogenic emissions on the global troposphere has been investigated in the Pacific Exploratory Missions (PEM) and the Transport and Atmospheric Chemistry near the Equator - Atlantic (TRACE-A).

The GTE, managed through the Tropospheric Chemistry Program in the Mission to Planet Earth Office, NASA Headquarters, was initiated in the early 1980s. Implementation of the GTE Project is via a Project Office at the NASA Langley Research Center, Atmospheric Sciences Division.

SYMBOLS AND UNITS

ABLE	Atmospheric Boundary Layer Experiment
CITE	Chemical Instrument Test and Evaluation
CO	carbon monoxide
CO ₂	carbon dioxide
C ₂ Cl ₄	tetrachloroethylene
CH ₃ CCl ₃	methyl chloroform
CH ₃ OOH	methyl peroxide
CH ₄	methane
DAAC	Distributed Active Archive Center
deg.	degree
dp	dew point temperature, degree Centigrade
Ga.Inst. of Tech.	Georgia Institute of Technology, Atlanta, Georgia
GTE	Global Tropospheric Experiment
H ₂ O ₂	hydrogen peroxide

HOCO	formaldehyde
HNO ₃	nitric acid
IGAC	International Global Atmospheric Chemistry Program
LaRC	Langley Research Center
MSL	mean sea level
N ₂ O	nitrous oxide
NASA	National Aeronautics and Space Administration
NP	national park
NO	nitric oxide
NO _x	nitrogen oxides (nitric oxide + nitrogen dioxide)
NO _y	total odd nitrogen
NCAR	National Center for Atmospheric Research
O ₃	ozone
PAN	peroxyacetyl nitrate
PEM	Pacific Exploratory Mission
ppbv	parts-per-billion, by volume
ppmv	parts-per-million, by volume
PPN	peroxypropionyl nitrate
pptv	parts-per-trillion, by volume
P. Rico	Puerto Rico
Rel. Humidity	relative humidity, percent
SAFARI	Southern African Fire-Atmosphere Research Initiative
S.Afr	South Africa
STARE	South Tropical Atlantic Regional Experiment
T	air temperature, degree Centigrade
Theta	potential temperature, degree Kelvin
TOMS	Total Ozone Measurements from Satellites
TRACE-A	Transport and Atmospheric Chemistry near the Equator - Atlantic
UK	United Kingdom

Univ. of CA, Irvine	University of California at Irvine, California
Univ. of NH	University of New Hampshire, Durham, New Hampshire
Univ. of RI	University of Rhode Island, Narragansett, Rhode Island

PROGRAM AND DATA DESCRIPTIONS

The National Aeronautics and Space Administration's TRACE-A conducted in September and October 1992 was a major component of the South Tropical Atlantic Regional Experiment (STARE), a project within the International Global Atmospheric Chemistry (IGAC) program. The focus of the STARE initiative is to study the impact of biomass burning on the biosphere and atmosphere. TRACE-A and its sister component of the 1992 STARE campaign, SAFARI (South African Fire-Atmosphere Research Initiative), had the broad objectives to study the impact of South American and African biomass burning and the impact of long-range transport of burning emissions on the south tropical Atlantic Ocean region. In particular, an objective of TRACE-A was to understand a region of seasonally (September/October) enhanced ozone observed (via satellites) off the west coast of southern Africa. It was hypothesized that the enhanced ozone was the result of widespread burning of vegetation in both South America and Africa.

The centerpiece of NASA's TRACE-A was a series of research flights with the instrumented NASA Ames DC-8. The aircraft operated from four staging areas: Brazil, South Africa, Namibia, and the Ascension Island. The primary bases of operation of Brasilia, Brazil; Johannesburg, South Africa; Windhoek, Namibia; and the Ascension Island were selected to allow sampling of biomass burning emissions from both continents at different ages after emission and during transport over the Atlantic Ocean. From these primary bases, flights covered a latitude range of about 35° N to the Equator and 50° W to 35°E longitude. Table 2 summarizes the flights, and Figure 2 shows the flight regions. Flights 1 and 2, the instrument checkout flights at Ames, are not

included in the table or figure, and the flight tracks for flights 3 and 19 and portions of the flight tracks for flights 4 and 18 are not shown in the figure. Flights 6-7, 10-11, 13-15, and 17 were site-intensive flights based from Brasilia, Johannesburg, Windhoek, and Ascension Island, respectively. Ferry/transit flights included (a) flights 3-5 from Ames to Brasilia (via Key West, Florida and Recife, Brazil); (b) flights 8-9 from Brasilia to Johannesburg (via Rio de Janeiro, Brazil); (c) flight 12 from Johannesburg to Windhoek; (d) flight 16 from Windhoek to Ascension Island; and (e) flights 18 and 19 from Ascension Island to Ames (via San Juan, Puerto Rico). Flights 1-2 were instrumentation verification flights and data are not reported. Flight plans consisted of combinations of controlled rate of ascent or descent spirals, ramp-up or ramp-down flight legs, and constant altitude flight legs selected to meet the scientific objectives of each flight. In general, 7- to 8-hour missions were flown covering an altitude range of 300 meters to about 13 km above mean sea level (MSL). Generally, altitude profiles (spirals or ramps) were flown with ascent/descent rates of 150 to 300 m/min.

The Brasilia-based flights focused on characterizing the chemical composition of air exiting the South American continent over the Atlantic Ocean. Flights 6 and 7 included upwind measurements in biomass burning source regions. Portions of ferry flights 4, 5, and 8 focused on continental outflow along the coast of Brazil. Deployment of the DC-8 aircraft from Ames was delayed ≈ 6 weeks and the Brasilia flights did not correspond to the time period in 1992 of most widespread burning in South America. However, significant active burning was occurring in the northwestern region of Brazil (see Figure 2 and flight 6 and 7 locations). The Johannesburg- and Windhoek-based flights permitted characterization of African biomass sources as well as air (outflow from and/or inflow to the continent) along both the Atlantic and Indian Ocean coasts of the continent. The 1992 prolonged drought in southern Africa, called by many the worst of the century, resulted in less biomass fauna for the region and, thus, the amount of burning relative to a normal year was much less. However, widespread burning in, north, and west of Zambia

did occur and was clearly visible from DC-8 flights over charred and smoldering areas with reduced visibility (flights 10 and 12). The Ascension Island flights, local (flight 17), arrival (flight 16), and departure (flight 18) provided an assessment of mid-ocean transport of emissions from both continents. These flights, combined with flights from Windhoek parallel to the coast of Africa, and from Brazil, also parallel to the coast, provided, perhaps, the first comprehensive assessment of the chemistry of tropospheric air within, flowing into, and exiting the Atlantic basin in this region. While the primary function of transit/ferry flights was to transport the aircraft between staging areas, portions of each flight were designed to provide additional data for understanding air chemistry within the Atlantic Basin; e.g., the southward dip associated with flight 9 from Rio de Janeiro to Johannesburg.

The core set of measurements aboard the aircraft focused on ozone and ozone precursors. The aircraft data included a suite of chemical measurements which included ozone, nitric oxide, nitrogen dioxide, total odd or "reactive" nitrogen gaseous species, peroxyacetyl nitrate or PAN, peroxypropionyl nitrate, methane, carbon monoxide, carbon dioxide, nonmethane hydrocarbons, fluorocarbons, acetic acid, formic acid, nitric acid, hydrogen and methyl peroxides, and aerosol number/size distribution. Table 3 identifies investigators responsible for the measurements, and Figure 3 shows a schematic of the instrumentation aboard the DC-8.

The TRACE-A DAAC data archive includes (1) data taken aboard the DC-8 aircraft; (2) data measured at surface sites throughout Brazil, (3) sondes released from multiple locations in support of the aircraft flights; and (4) numerous meteorological, land-use, and satellite data products used in flight (field) planning and post-mission analyses. SAFARI data are not archived in the DAAC. The archive does include pre-TRACE (1990-1991) ozonesonde data from coordinated releases at Ascension Island; Brazzaville, Congo; and Natal, Brazil.

The data plots for the TRACE-A are given in Appendix A. For each flight, six pages of time series plots are provided: page 1 -- a pictorial diagram of the flight region/flight plan and time series plots of altitude, temperature (T), dew point temperature (dp), relative humidity, and potential temperature (theta); page 2 -- ozone (O_3), carbon monoxide (CO), carbon dioxide (CO_2), methane, nitrous oxide (N_2O), and benzene; page 3 -- nitric oxide (NO), nitrogen oxides (NO_x), total odd or "reactive" nitrogen gas species (NO_y), peroxyacetyl nitrate (PAN), and nitric acid; page 4 -- acetylene, ethane, propane, ethylene, and acetone; page 5 -- methyl chloride (CH_3Cl), tetrachloroethylene (C_2Cl_4), methyl chloroform (CH_3CCl_3), hydrogen peroxide (H_2O_2), and formaldehyde (HOCO); and page 6 -- methyl peroxide and fine aerosol (0.3 to 3.1 μm diameter). The species were selected to provide the reader with information on both the source characteristics and photochemical history of the air. Figure numbers correspond to flight numbers; e.g., Figure A4.2 represents page 2 of the plots for flight #4. Selected profile plots follow the time series plots as, e.g., Figure A4.7 is the first page of profile plots for flight 4. Profile plot sets include temperature, dew point temperature, ozone, carbon monoxide, and methane data plotted to the same altitude scale. One to four sets of profile plots are provided (format of two sets per page) for each flight. Table 4 summarizes the profiles selected. There are no figures with the prefix of A1 or A2 as flights 1 and 2 (instrument checkout flights) data were not archived. Data plots are in standardized format as discussed in Appendix A. The DAAC archive includes measurements aboard the DC-8 aircraft during TRACE-A which are not plotted in Appendix A.

CONCLUDING REMARKS

This compendium of data from NASA's Global Tropospheric Experiment's Transport and Atmospheric Chemistry near the Equator - Atlantic (TRACE-A) provides only a representation of aircraft data that are available in archived format from NASA Langley's Distributed Active Archive Center (DAAC). The presented data are not intended to support original research/analyses, but serve as an overview of the TRACE-A data and provide some assistance to the reader in identifying data that are of interest and which may be obtained from Langley's DAAC archive. This compendium covers only selected NASA DC-8 aircraft data. The archived data bases include other data measured on board the aircraft as well as numerous supporting data including meteorological observations/products, photochemical modeling products, surface station observations, satellite observations, and sondes releases. GTE-sponsored analyses/results from the TRACE-A expeditions have been submitted (March 1995) to a Special Issue of the Journal of Geophysical Research - Atmospheres.

Questions or information regarding the Langley DAAC archive should be directed to Langley DAAC User and Data Services, Mail Stop 157B, NASA Langley Research Center, Hampton, Virginia 23681-0001. A brief description of the DAAC, log on procedures, and data bases is given as Appendix B.

TABLE 1. GTE Field Expeditions

Expedition	Date	General Geographic Region	Time of Year
ABLE-1	1984	Barbados, French Guyana	June
ABLE-2A	1985	Amazon Basin	August
ABLE-2B	1987	Amazon Basin	May
ABLE-3A	1988	Alaska--Barrow, Bethel, Cold Bay	July/August
ABLE-3B	1990	Canada--Hudson Bay, Schefferville	July/August
CITE-1	1983	Hawaii	November
CITE-1	1984	Eastern North Pacific--off the California coast	April
CITE-2	1986	Western USA	August
CITE-3	1989	Western North Atlantic--Virginia coast and Western South Atlantic--Brazil coast	August September
PEM West-A	1991	Western Pacific Rim	October
PEM West-B	1994	Western Pacific Rim	Feb./March
TRACE-A	1992	Brazil, South Atlantic, southwest Africa	September

TABLE 2. Summary of the Flights Conducted during the 1992 TRACE-A Expedition
(All times are GMT)

Mission Number	Flight Date	Departure		Arrival		Purpose
		Time	Location	Time	Location	
3	Sept. 21	1516	NASA Ames	2024	Key West, Florida	ferry
4	Sept. 22	1200	Key West	1937	Receife, Brazil	survey & ferry
5	Sept. 24	1207	Receife	1900	Brasila, Brazil	ferry & continental outflow
6	Sept. 27	0912	Brasila	1651	Brasila, Brazil	source charaacterization
7	Sept. 28	1400	Brasila	1922	Brasila, Brazil	source characaterization
8	Oct. 1	1207	Brasila	1923	Rio de Janeiro	ferry & continental outflow
9	Oct. 3	0736	Rio de Janeiro	1558	Johannesburg, S.Afr.	survey & ferry
10	Oct. 6	0717	Johannesburg	1428	Johannesburg	source characterization
11	Oct. 9	0653	Johannesburg	1421	Johannesburg	Indian Ocean Coast
12	Oct. 11	0800	Johannesburg	1302	Windhoek, Namibia	ferry & source characterization
13	Oct. 14	0713	Windehoek	1415	Windhoek	continental outflow
14	Oct. 15	0721	Windhoek	1504	Windhoek	continental outflow
15	Oct. 18	0930	Windhoek	1715	Windhoek	continental outflow
16	Oct. 20	0758	Windhoek	1450	Ascension Island	survey & ferry
17	Oct. 22	0902	Ascension Island	1623	Ascension Island	survey & continental outflow
18	Oct. 24	0859	Ascension Island	1648	San Juan, P. Rico	survey & ferry
19	Oct. 26	1348	San Juan	2133	NASA Ames	ferry

TABLE 3. Principal Investigators and Institutions Participating in Transport and Atmospheric Chemistry near the Equator - Atlantic

Investigator	Institution	Investigation/Measurement
Bruce Anderson	NASA Langley Research Center	carbon dioxide
John Barrick	NASA Langley Research Center	airborne meteorological/position data
John Bradshaw	Georgia Institute of Technology	nitric oxide, nitrogen dioxide, total oxides of nitrogen
Edward Browell	NASA Langley Research Center	ozone & aerosol profiles (remote sensor)
Gerald Gregory	NASA Langley Research Center	ozone, aerosols (in situ)
Brian Heikes	University of Rhode Island	hydrogen and methyl peroxides, formaldehyde
Dean Lauritsen	NCAR Boulder Laboratory	drop sondes
Sherry Rowland	University of California, Irvine	nonmethane hydrocarbons
Glen Sachse	NASA/Langley Research Center	carbon monoxide, methane, nitrous oxide
Hanwant Singh	NASA Ames Research Center	PAN, PPN, C ₂ Cl ₄ , CH ₃ ONO ₂ , acetone
Robert Talbot	University of New Hampshire	HNO ₃ , gas phase organic acids

TABLE 4. TRACE-A Profiles

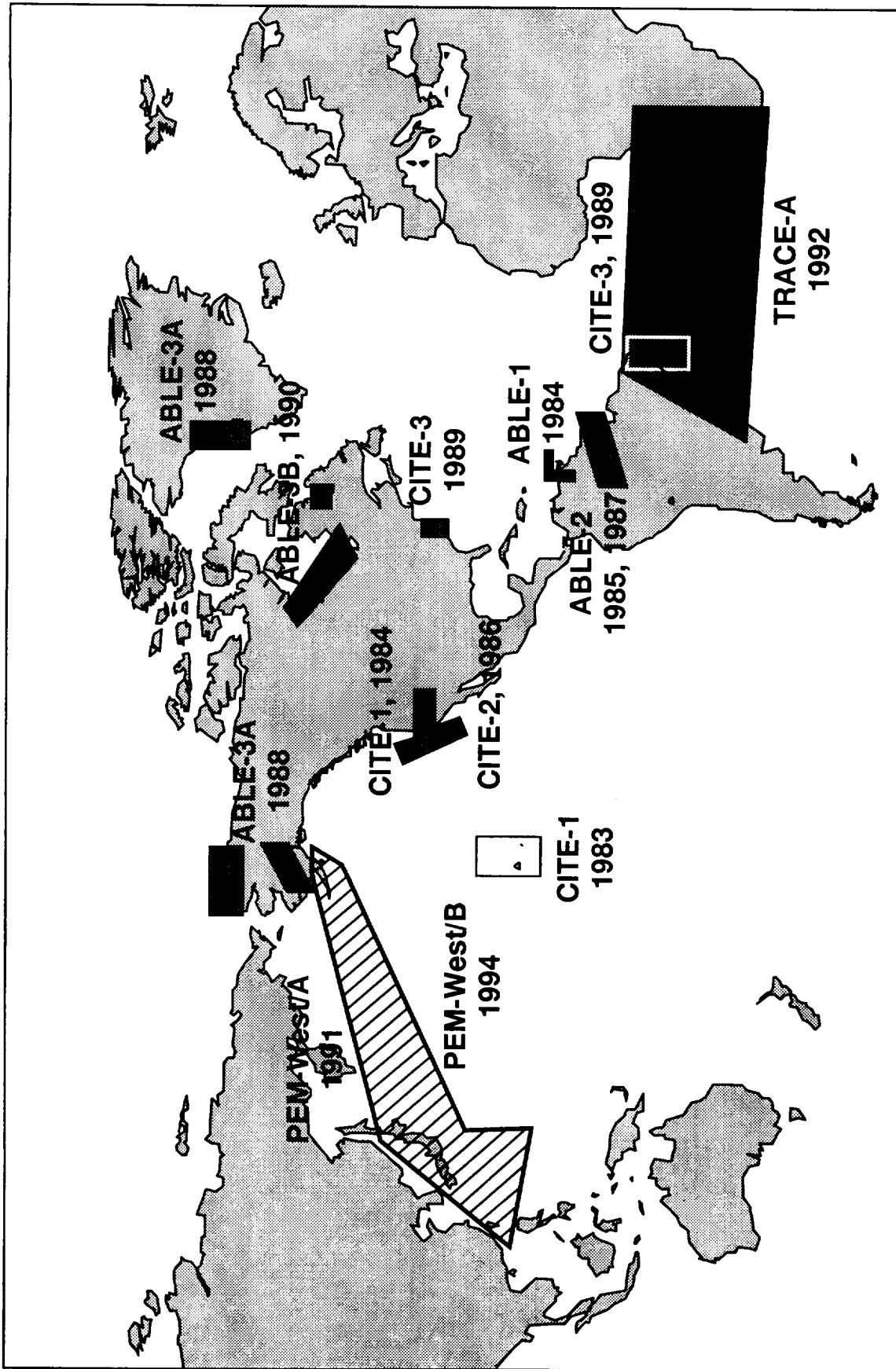
Flight	Date	Time	Latitude, °N	Longitude, °E
3	September 21	1530	- 25.2	- 82.1
4	September 22	2015	- 7.7	- 35.2
5	September 24	1600	- 28.2	- 43.8
5	September 24	1845	- 16.3	- 48.3
6	September 27	1100	- 8.9	- 44.3
6	September 27	1400	- 9.0	- 48.8
6	September 27	1530	- 9.0	- 44.3
6	September 27	1645	- 15.35	- 47.6
7	September 28	1415	- 14.8	- 47.2
7	September 28	1815	- 12.6	- 44.8
8	October 1	1600	- 30.2	- 44.9
8	October 1	1915	- 23.3	- 43.7
9	October 3	0800	- 23.3	- 42.1
9	October 3	1545	- 26.7	27.4
10	October 6	0830	- 21.9	28.1
10	October 6	1415	- 25.9	28.0
11	October 9	0930	- 23.0	39.3
11	October 9	1200	- 35.9	30.8
12	October 11	0815	- 22.0	24.8
12	October 11	1245	- 21.9	16.8
13	October 14	1030	- 5.8	8.7
13	October 14	1300	- 20.0	9.2

Times are GMT

TABLE 4. Profiles continued.

Flight	Date	Time	Latitude, °N	Longitude, °E
14	October 15	1045	- 6.1	3.4
14	October 15	1330	- 21.1	9.1
15	October 18	0945	- 22.0	16.4
15	October 18	1500	- 12.1	2.4
16	October 20	0815	- 22.1	15.9
16	October 20	1430	- 8.4	- 15.4
17	October 22	1100	- 17.9	- 20.3
17	October 22	1430	0.4	- 10.4
18	October 24	0915	- 7.4	- 15.6
18	October 24	1630	18.2	- 65.3
19	October 26	1430	19.6	- 67.1
19	October 26	2115	36.5	-121.1

Times are GMT



GG-GTE-Paper-1/95

Figure 1: GTE mission sites

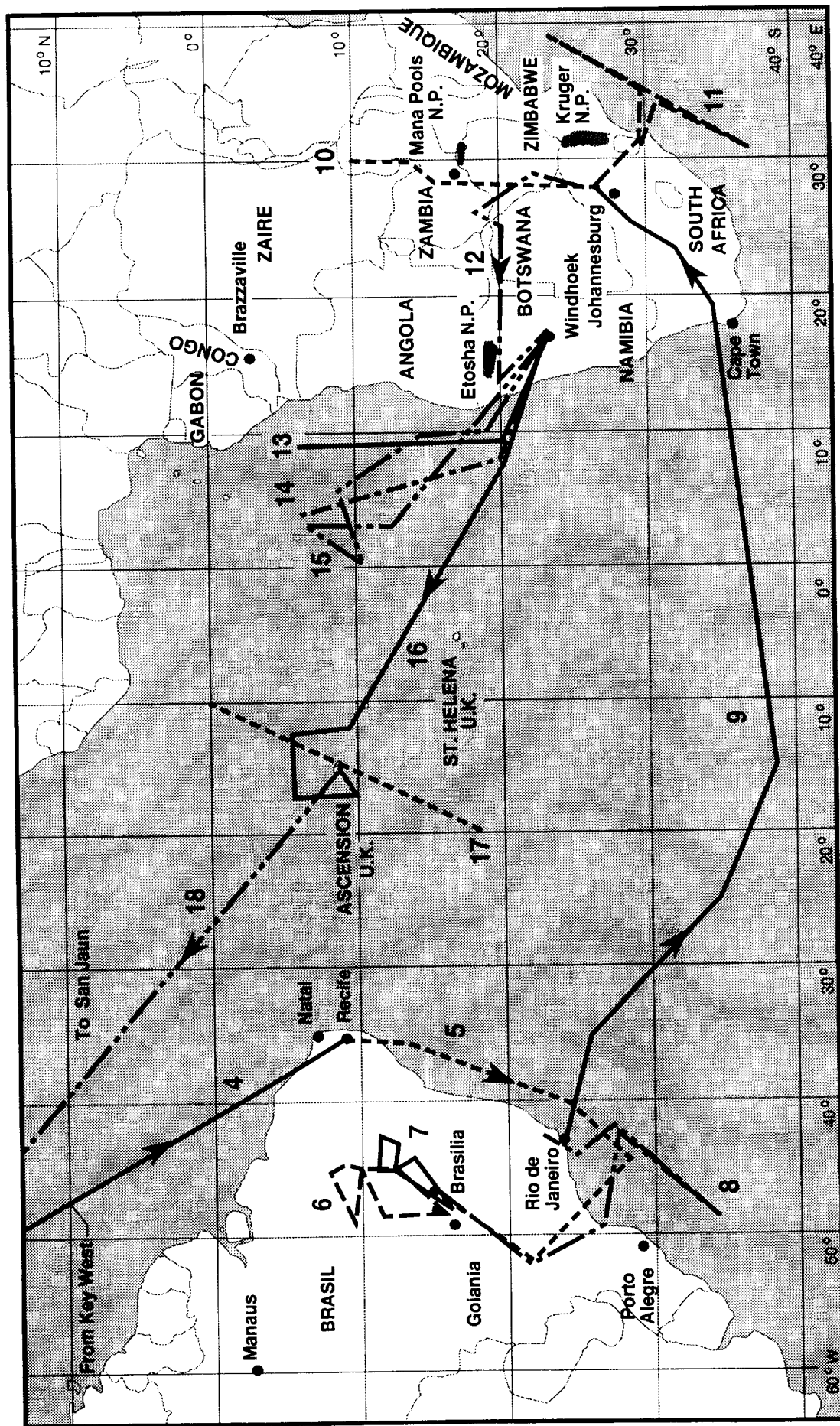


Figure 2: TRACE-A DC-8 flight tracks

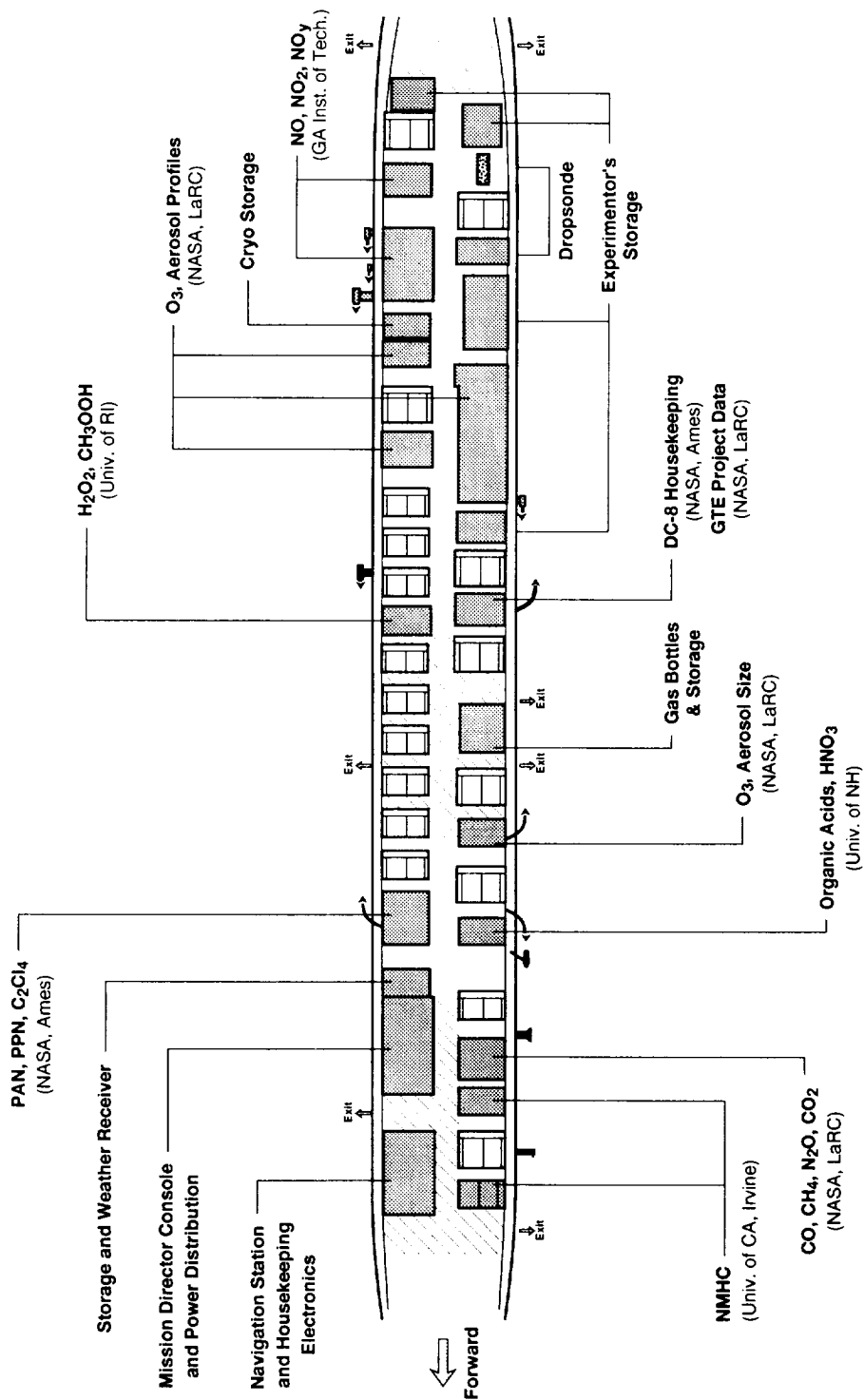


Figure 3: Instrument location on the NASA DC-8 aircraft

APPENDIX A: TRACE-A DATA PLOTS

Plots are presented in a standardized format, and the data (unedited) are from the Langley DAAC archive. Relative humidity and potential temperature are calculated from measurements made on the aircraft. In some cases (mostly for moist, boundary layer conditions) relative humidity may exceed 100% (not plotted) as dew point temperature exceeded air temperature by a few degrees (assumed to be the result of instrument measurement/calibration uncertainty). For time series plots, abscissa time scales for a given flight are identical. Ordinate scales for O_3 , CO, NO, NO_x , NO_y , and fine aerosol are different for some flights. Ordinate scales for all other species are identical among all flights. Ordinate scales were selected to best represent all the data for a specie measured during the flight or expedition; thus, some data may be off-scale. As a result of the software used for the plots and the data archive use of codes (in place of valid data) for data taken (1) during instrument calibration, (2) when measurements were at "detection limit," and/or (3) when measurements were invalid, it is sometimes difficult to distinguish from the plots if data are off-scale or coded as invalid. For example, a symbol without an attached line may either mean that adjacent data are off-scale or have been coded as invalid. Inspection of the other plotted data often provides information which resolves the uncertainty. For profile plots, altitude scales are identical for all plots and the specie scales are those selected for the time series plots. In order to maintain the standardized format, plots for flights in which a specie data were not reported are plotted with the axes and a "NO DATA" entry.

Given below are the beginning page numbers for each flight's sequence of plots:

Flight 3 - page 23

Flight 4 - page 31

Flight 5 - page 39

Flight 6 - page 47

Flight 7 - page 55
Flight 8 - page 63
Flight 9 - page 71
Flight 10 - page 79
Flight 11 - page 87
Flight 12 - page 95
Flight 13 - page 103
Flight 14 - page 111
Flight 15 - page 119
Flight 16 - page 127
Flight 17 - page 135
Flight 18 - page 143
Flight 19 - page 151

TRACE-A ATLANTIC MISSION: FLIGHT 3

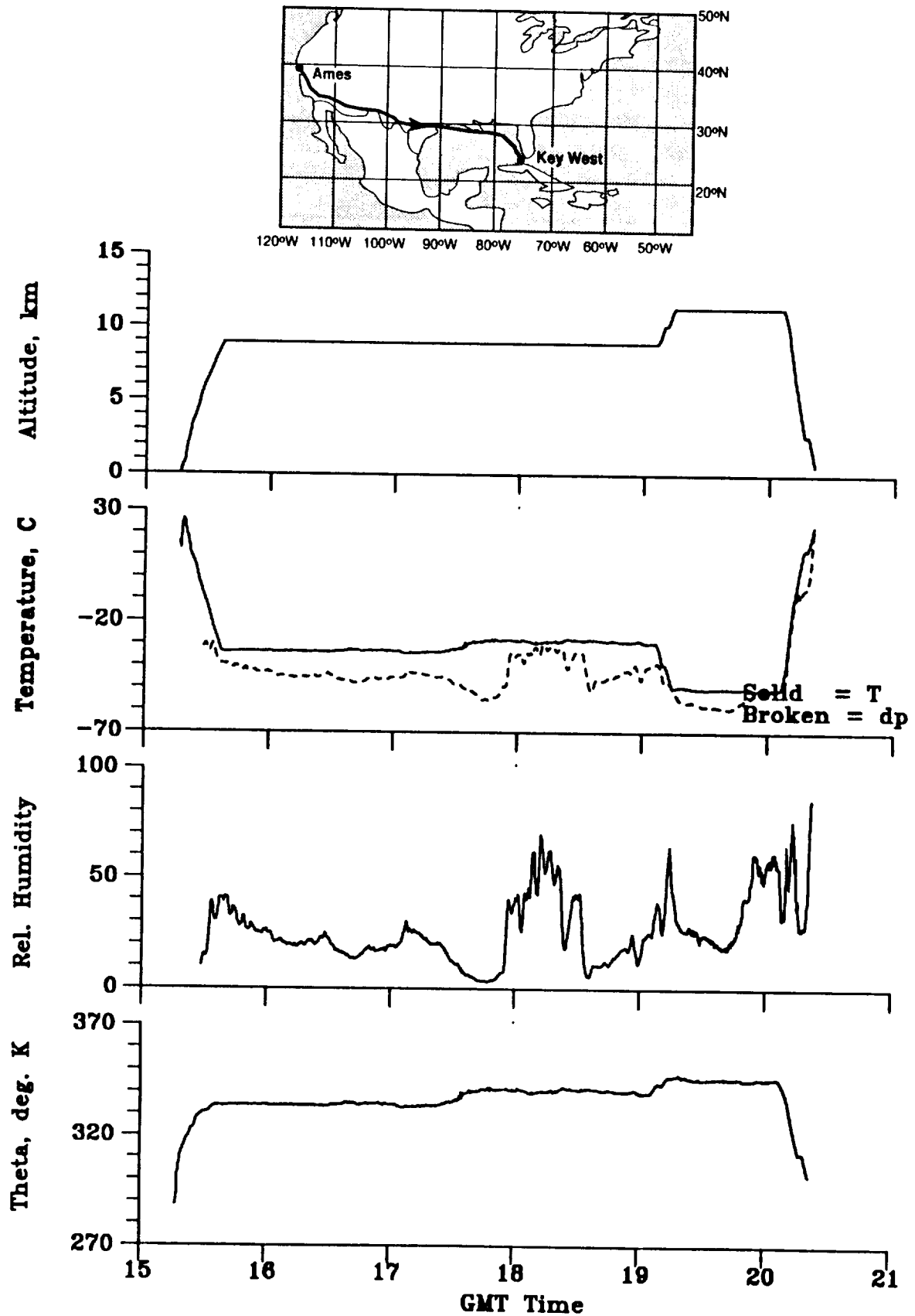


Figure A3.1

TRACE-A ATLANTIC MISSION: FLIGHT 3

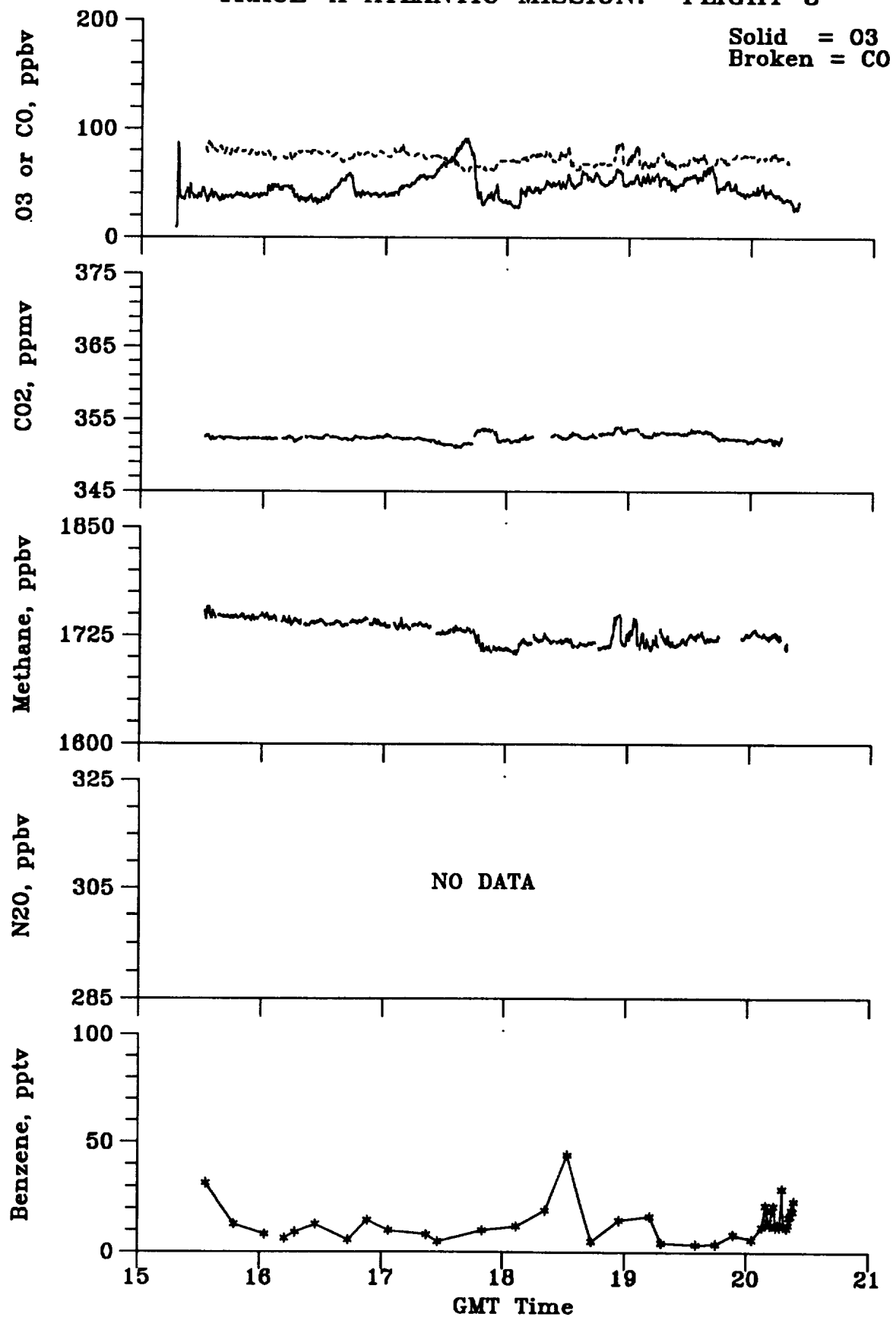


Figure A3.2

TRACE-A ATLANTIC MISSION: FLIGHT 3

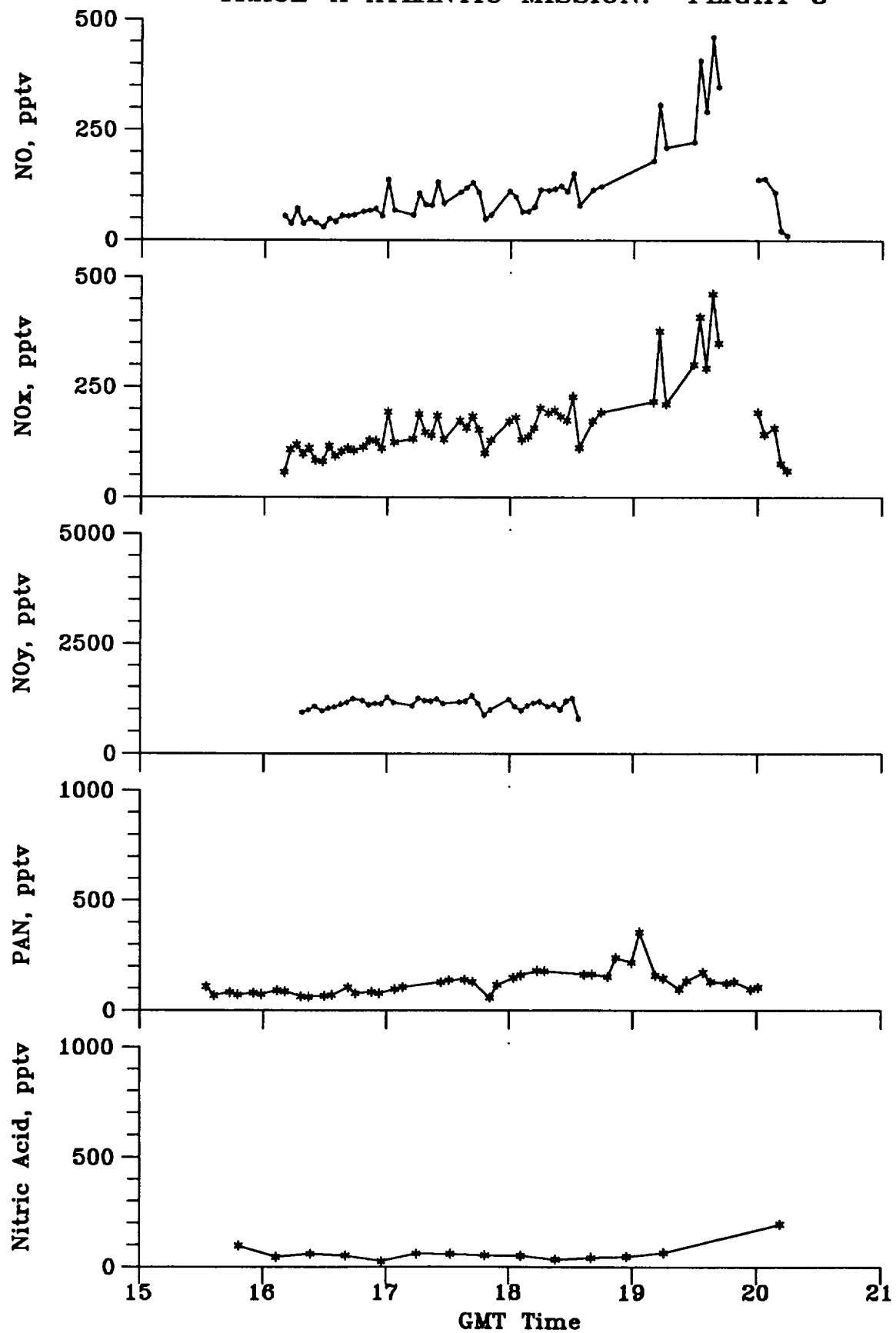


Figure A3.3

TRACE-A ATLANTIC MISSION: FLIGHT 3

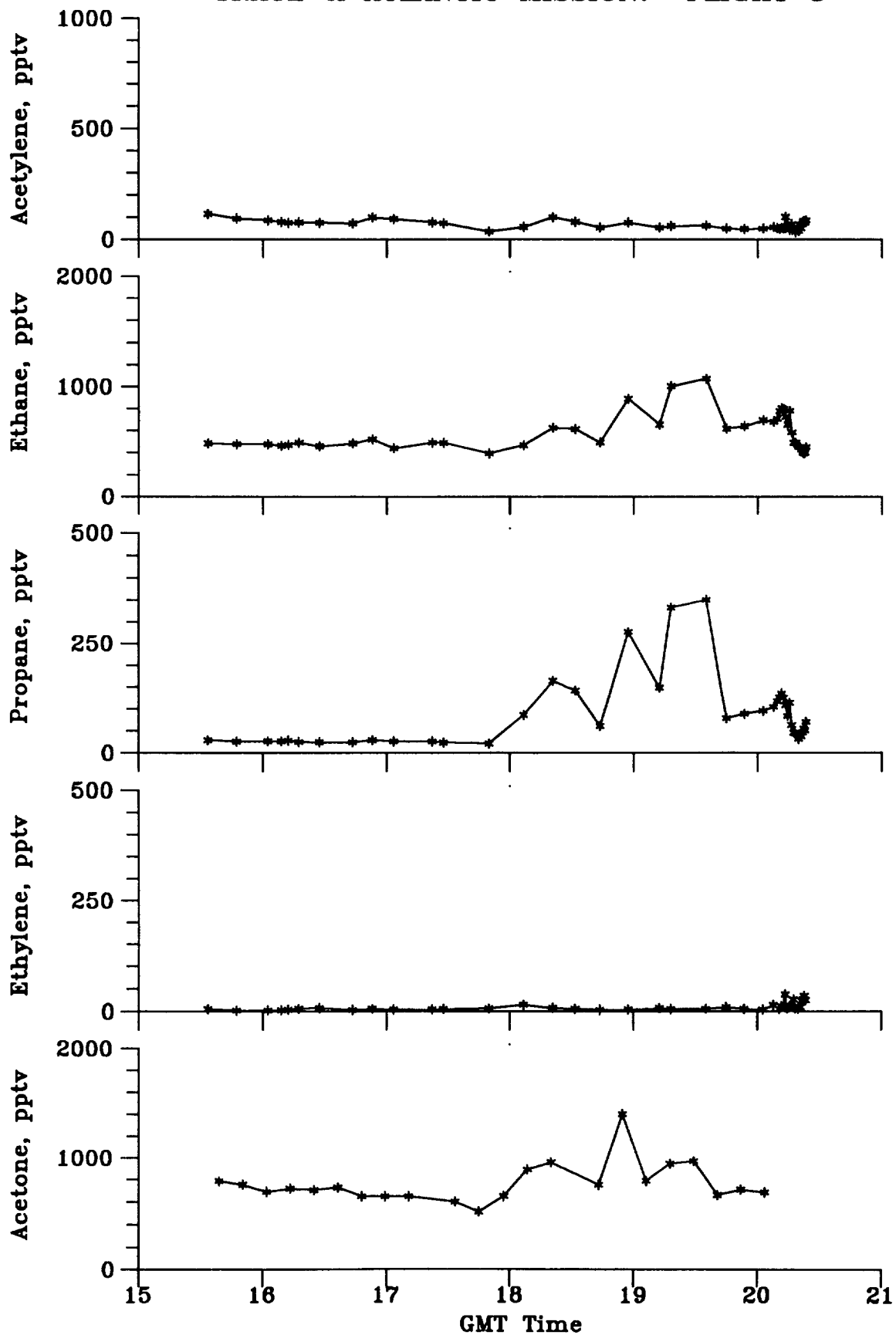


Figure A3.4

TRACE-A ATLANTIC MISSION: FLIGHT 3

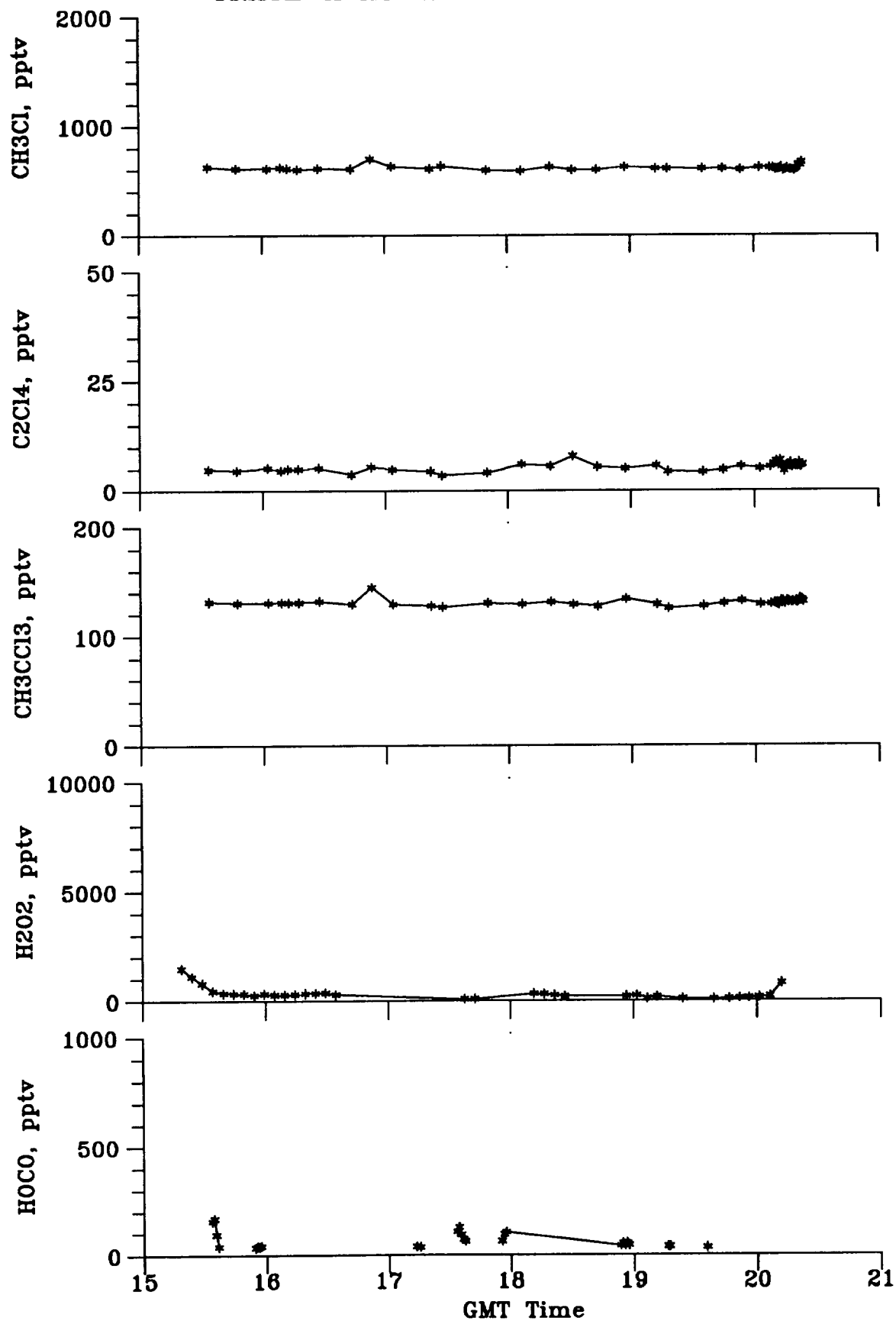


Figure A3.5

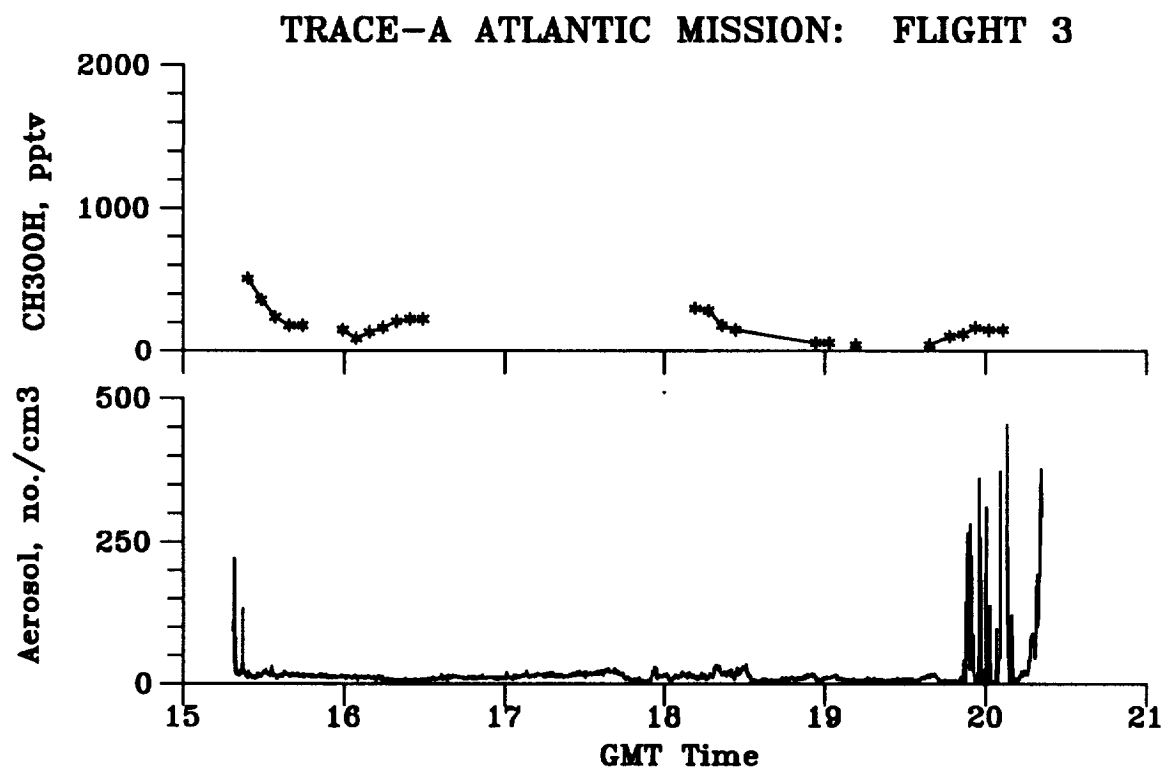


Figure A3.6

TRACE (A) ATLANTIC MISSION: FLIGHT 3 PROFILE AT 2015 GMT

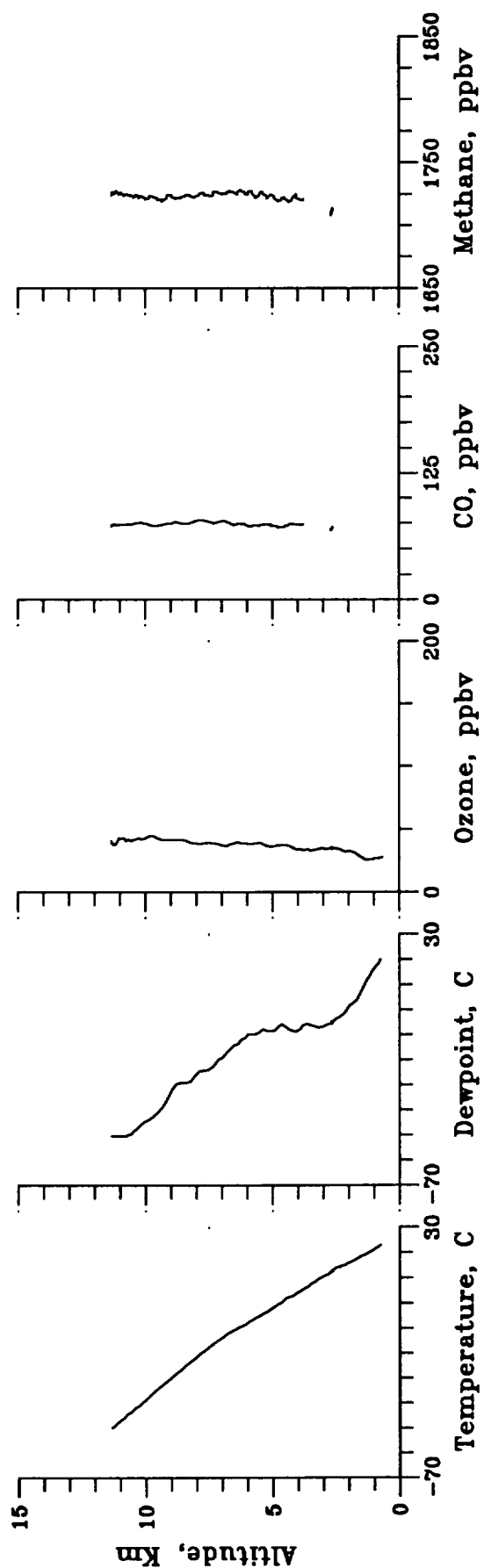


Figure A3.7

TRACE-A ATLANTIC MISSION: FLIGHT 4

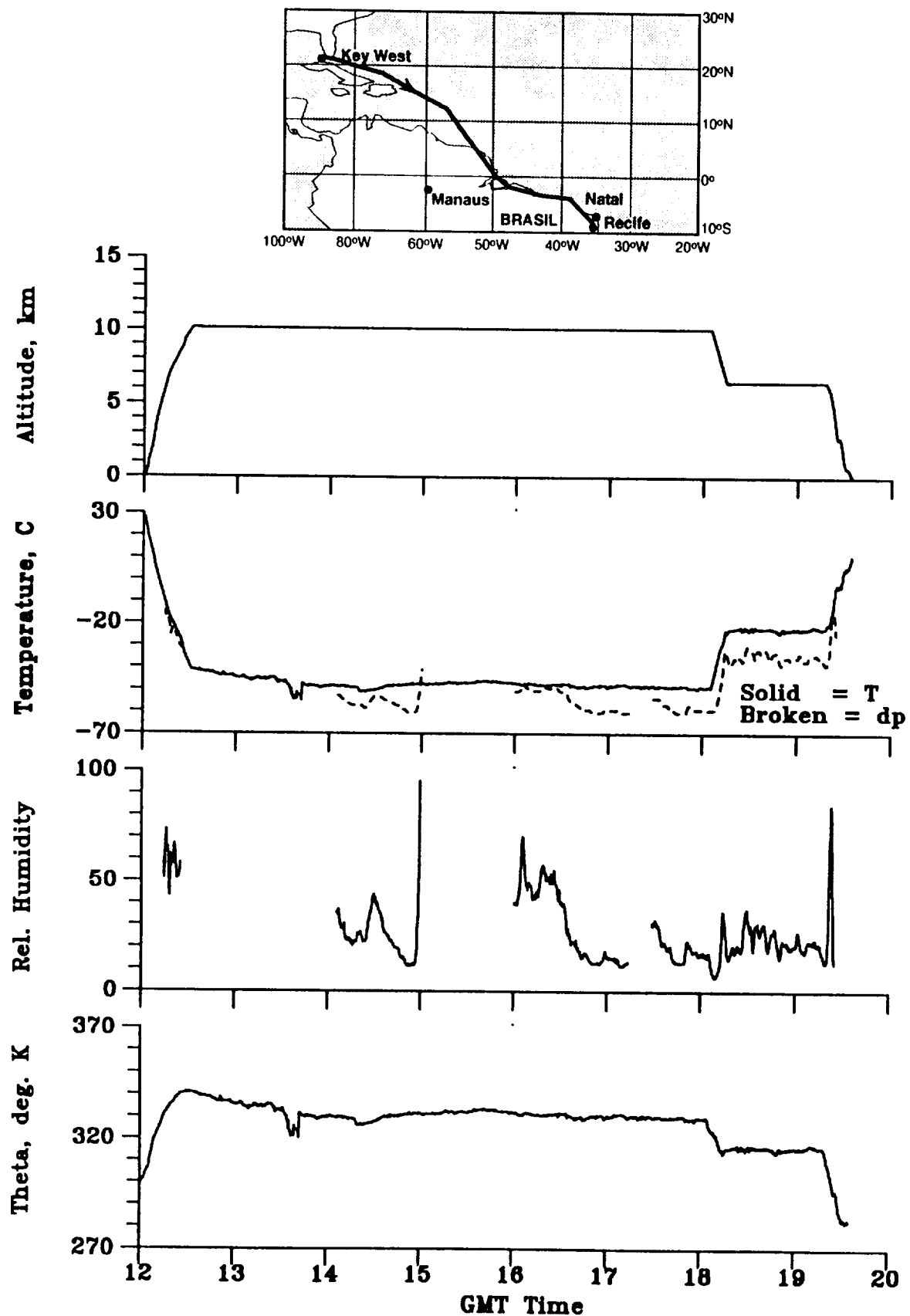


Figure A4.1

TRACE-A ATLANTIC MISSION: FLIGHT 4

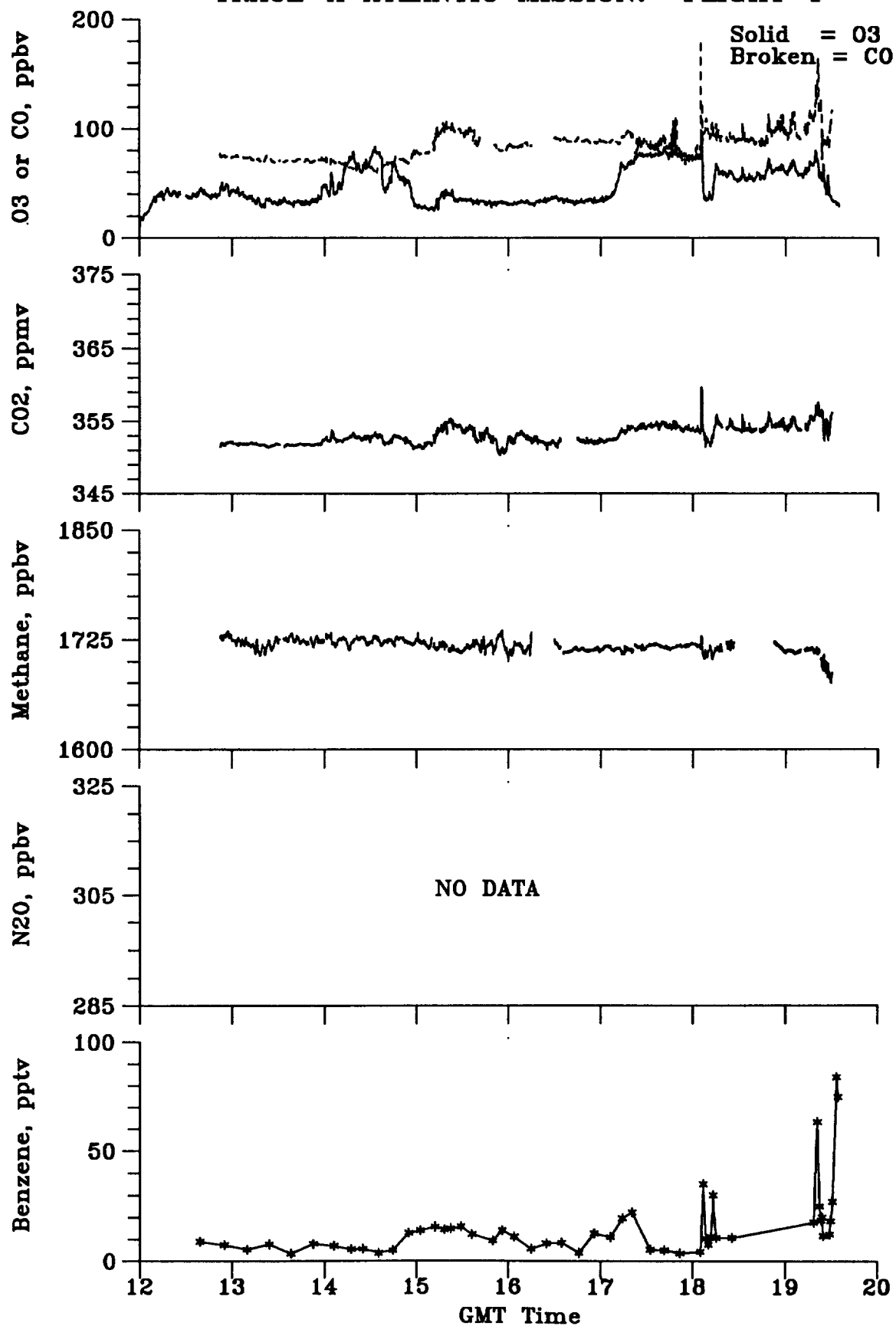


Figure A4.2

TRACE-A ATLANTIC MISSION: FLIGHT 4

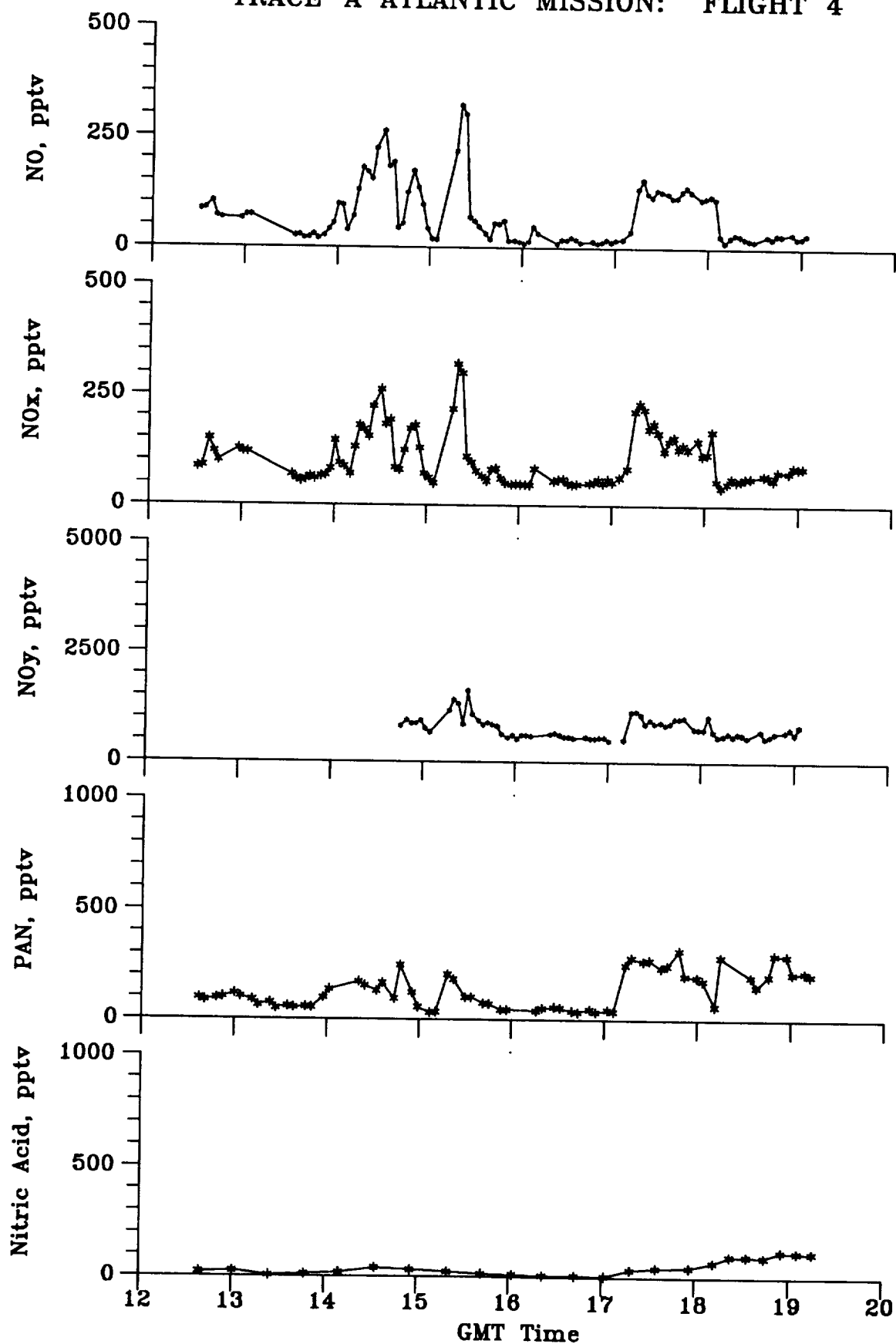


Figure A4.3

TRACE-A ATLANTIC MISSION: FLIGHT 4

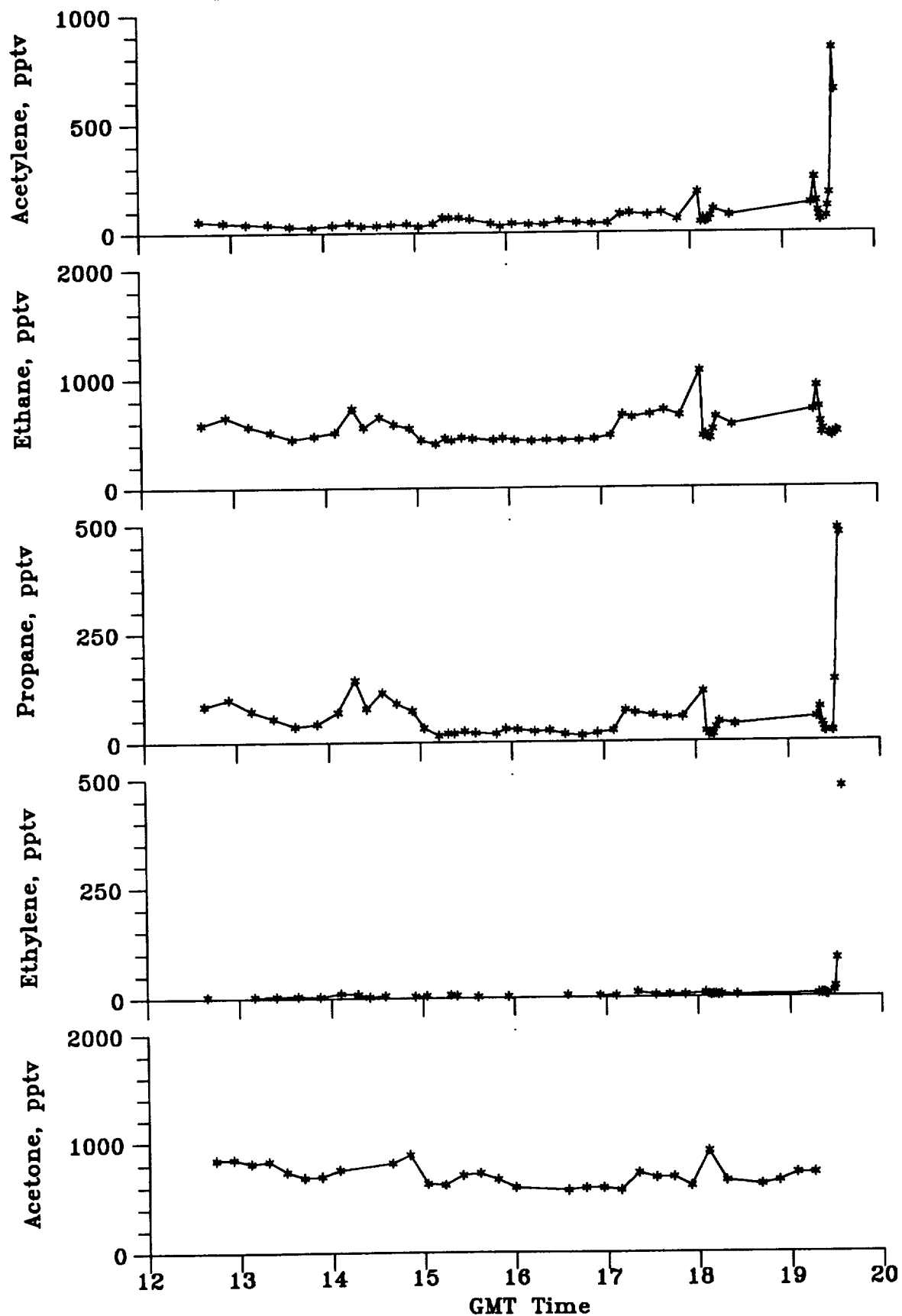


Figure A4.4

TRACE-A ATLANTIC MISSION: FLIGHT 4

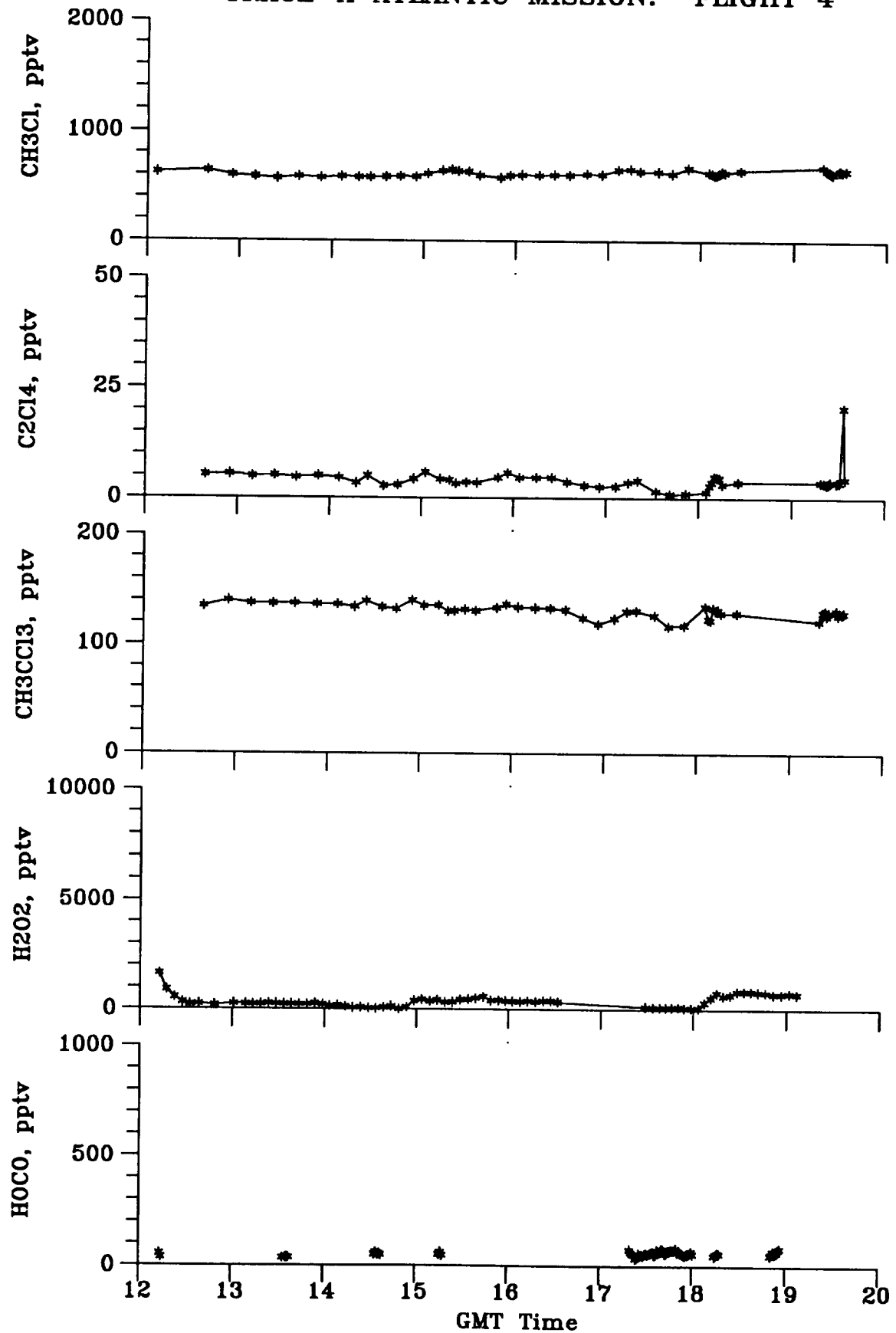


Figure A4.5

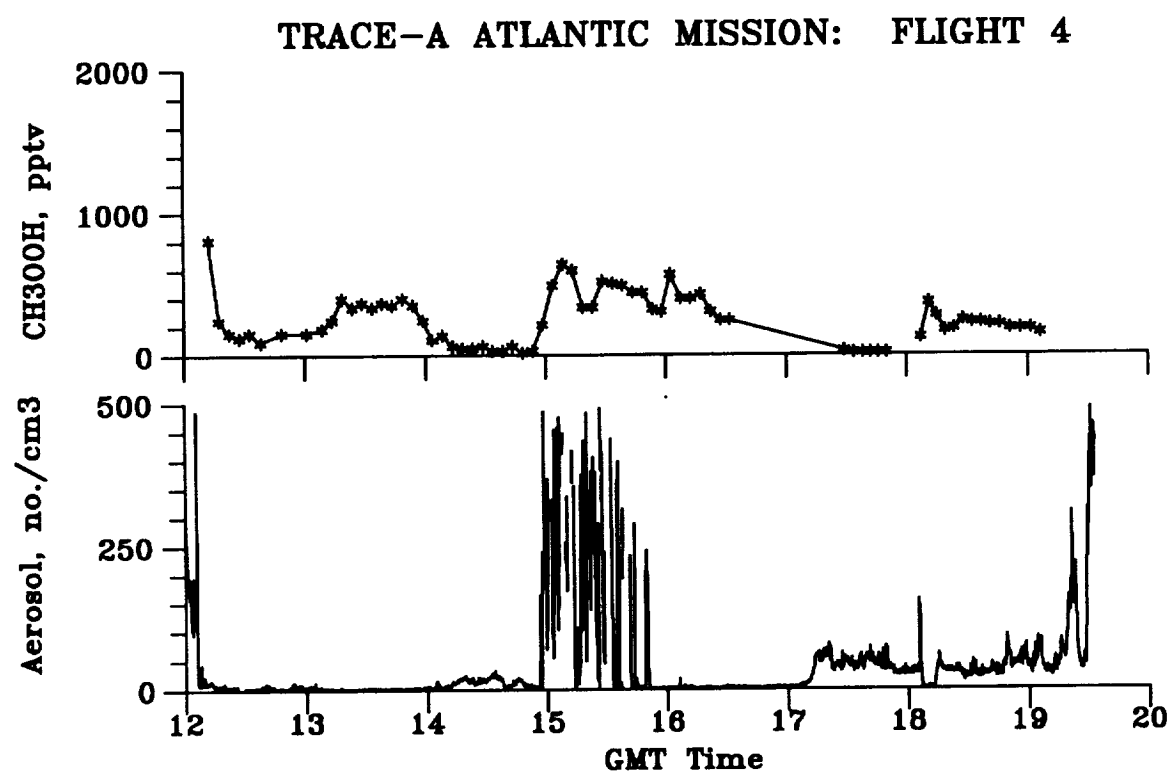


Figure A4.6

TRACE (A) ATLANTIC MISSION: FLIGHT 4 PROFILE AT 1930 GMT

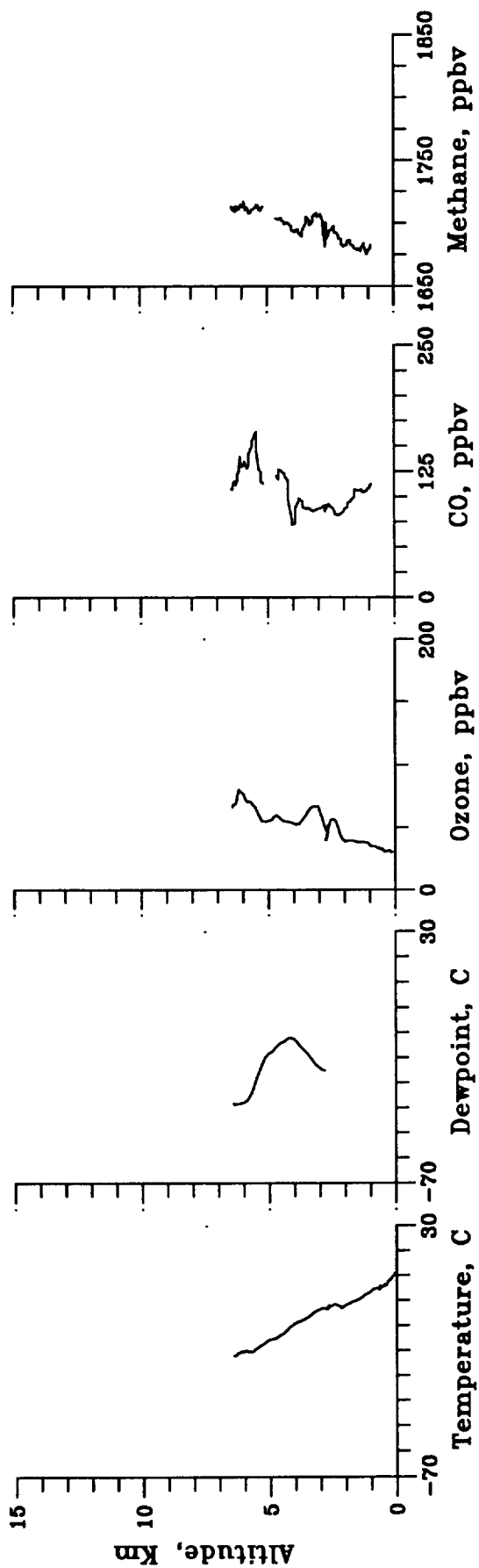


Figure A4.7

TRACE-A ATLANTIC MISSION: FLIGHT 5

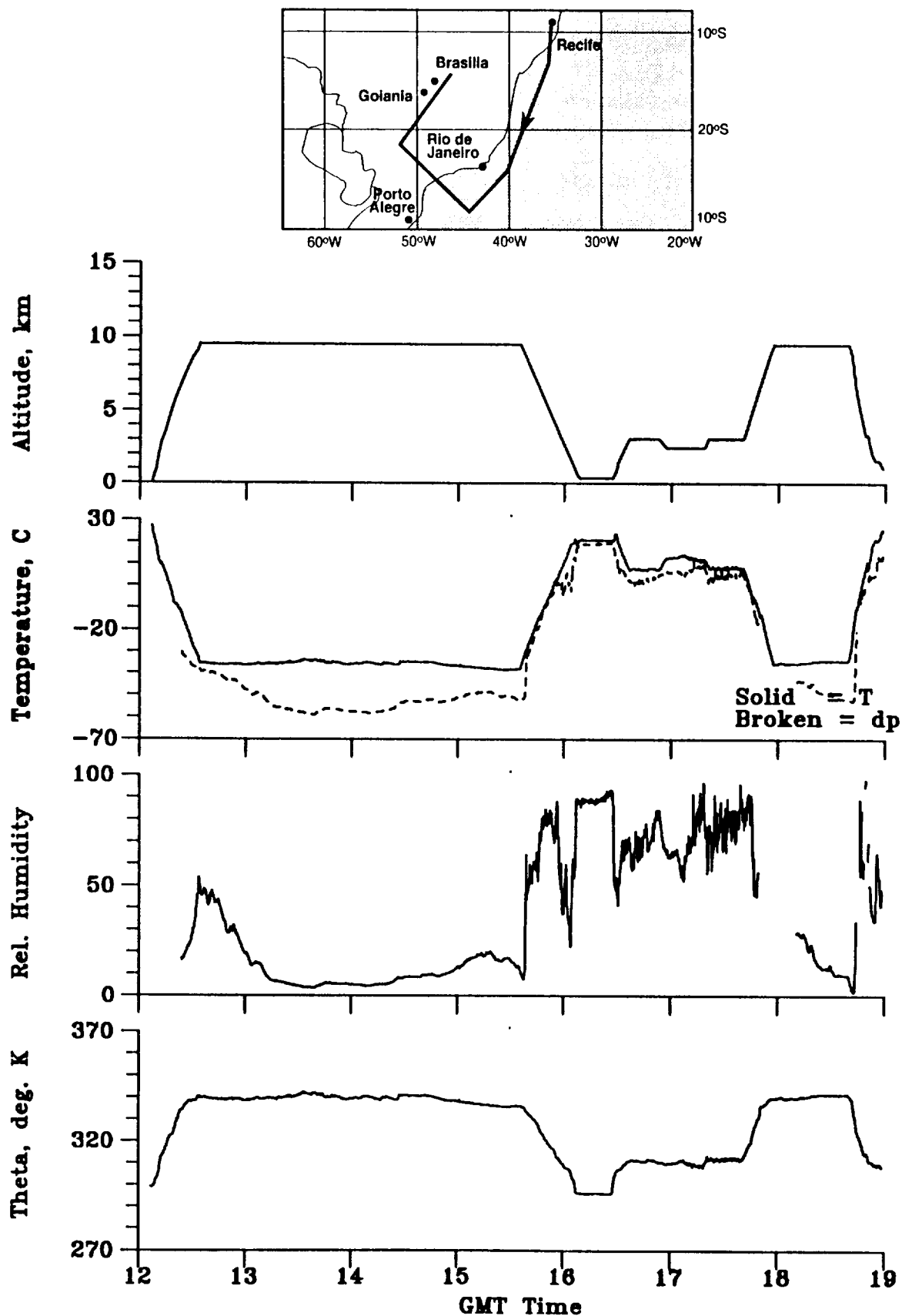


Figure A5.1

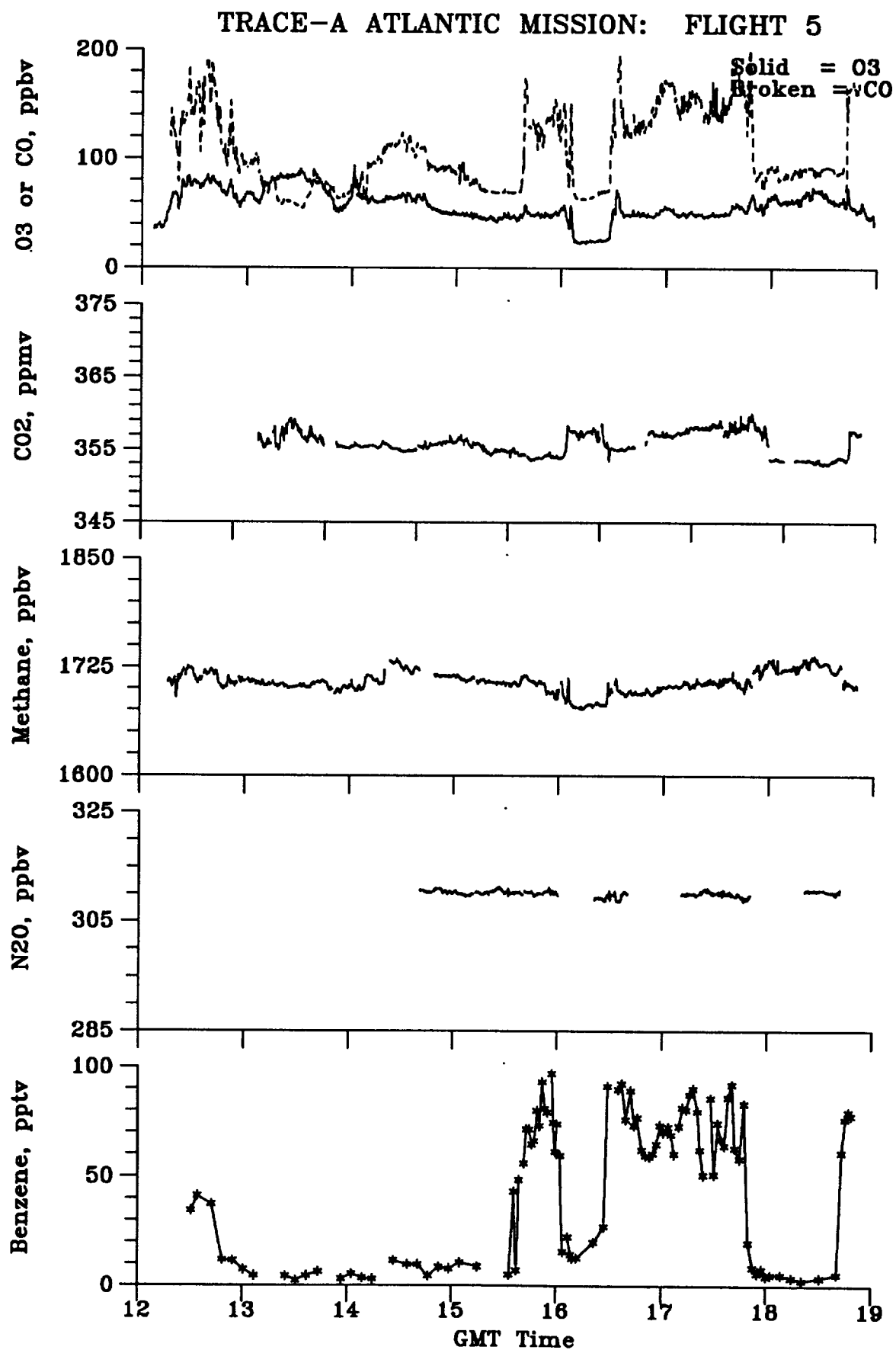


Figure A5.2

TRACE-A ATLANTIC MISSION: FLIGHT 5

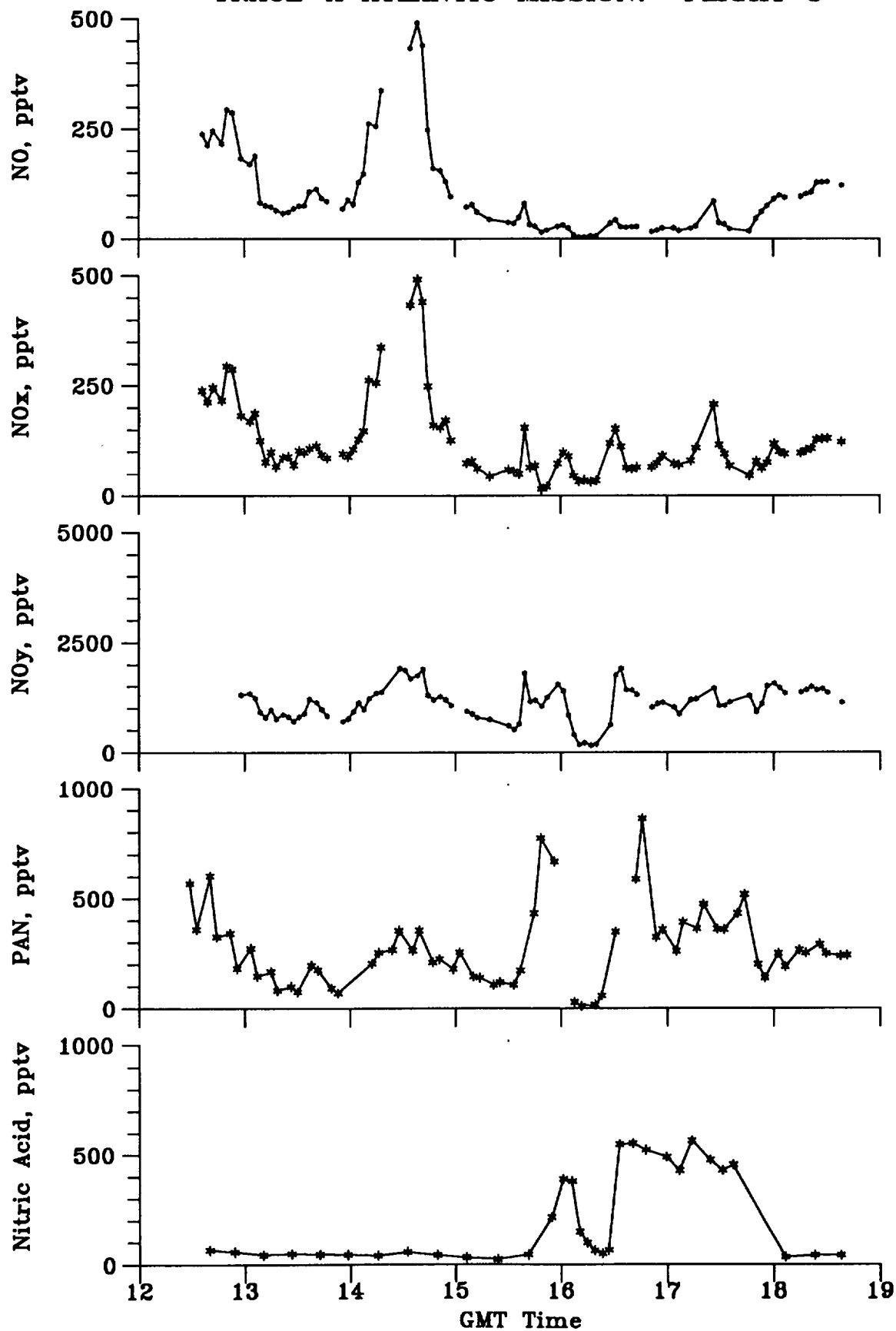


Figure A5.3

TRACE-A ATLANTIC MISSION: FLIGHT 5

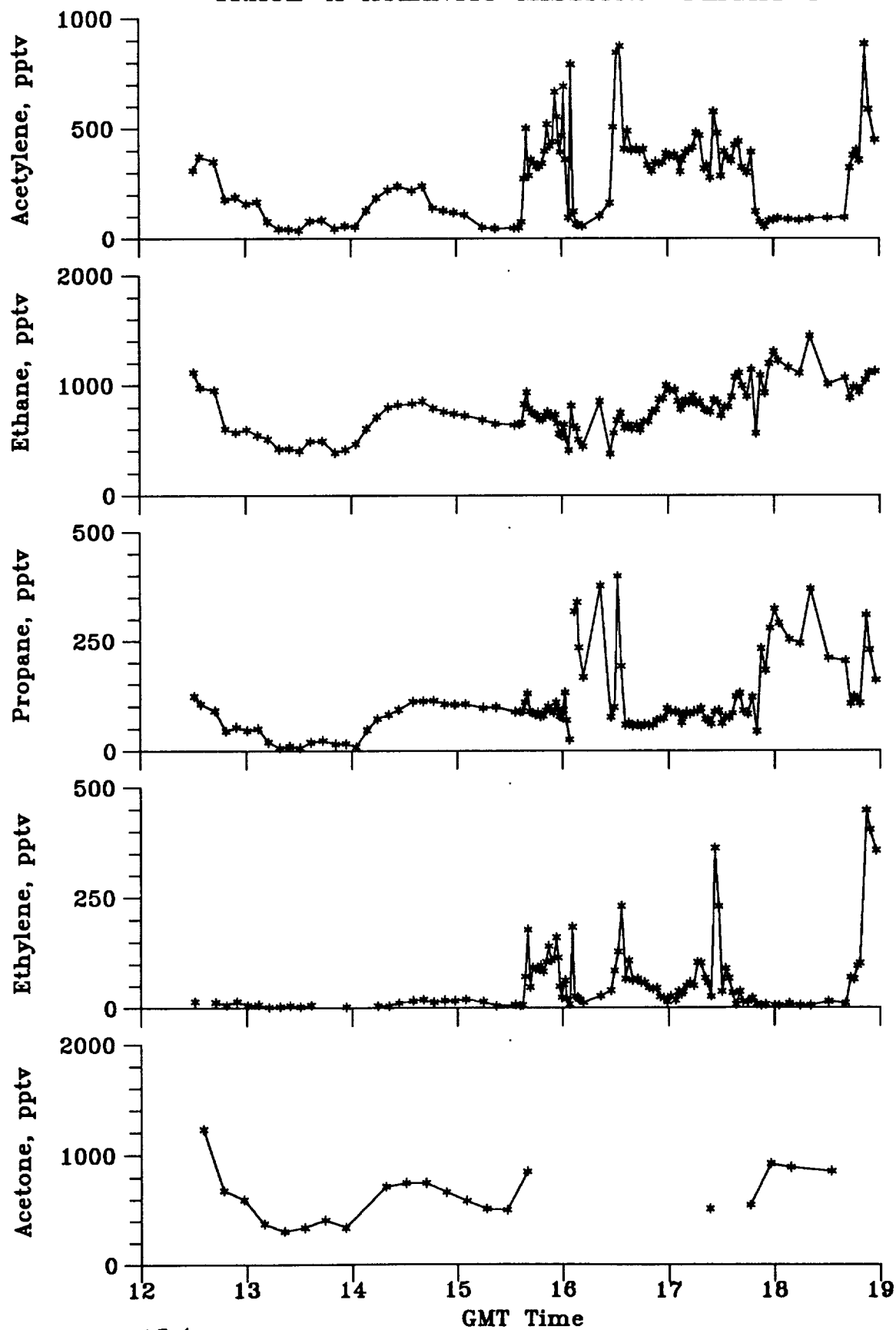


Figure A5.4

TRACE-A ATLANTIC MISSION: FLIGHT 5

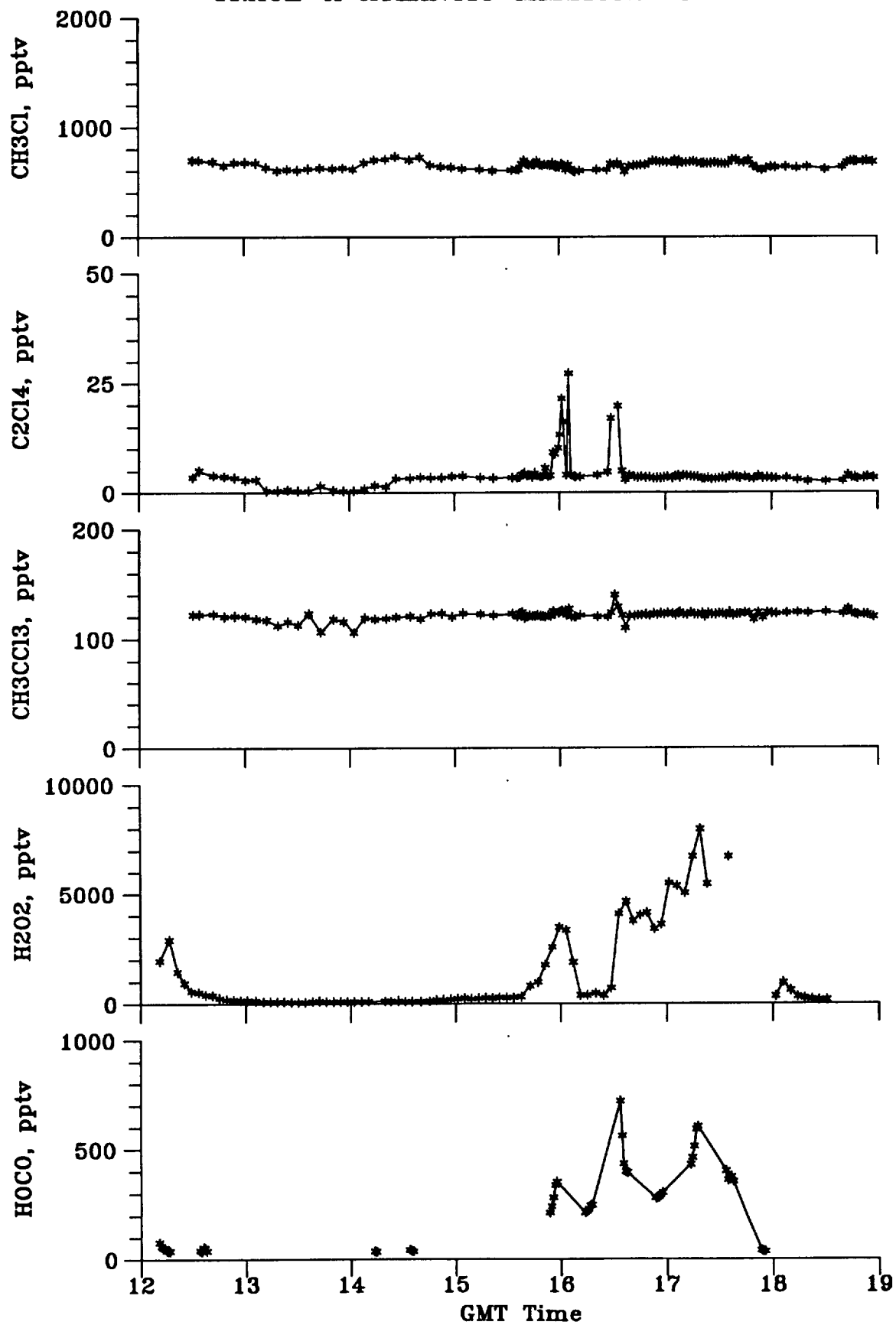


Figure A5.5

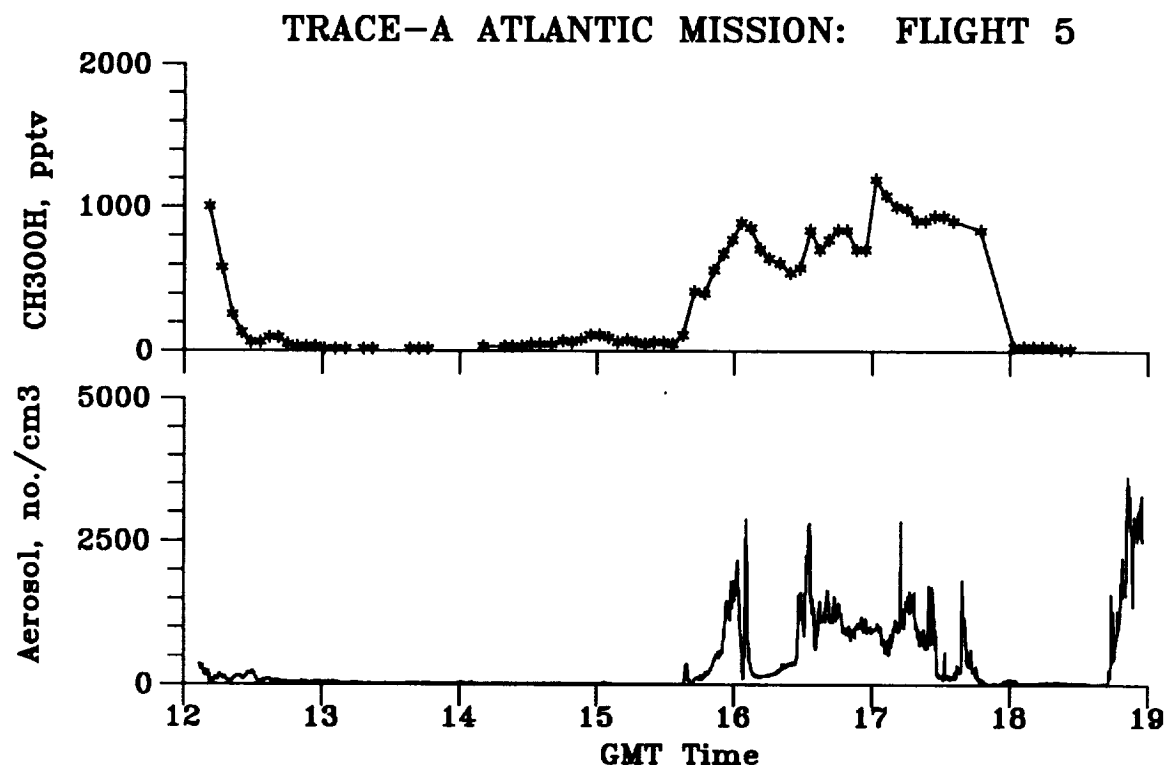
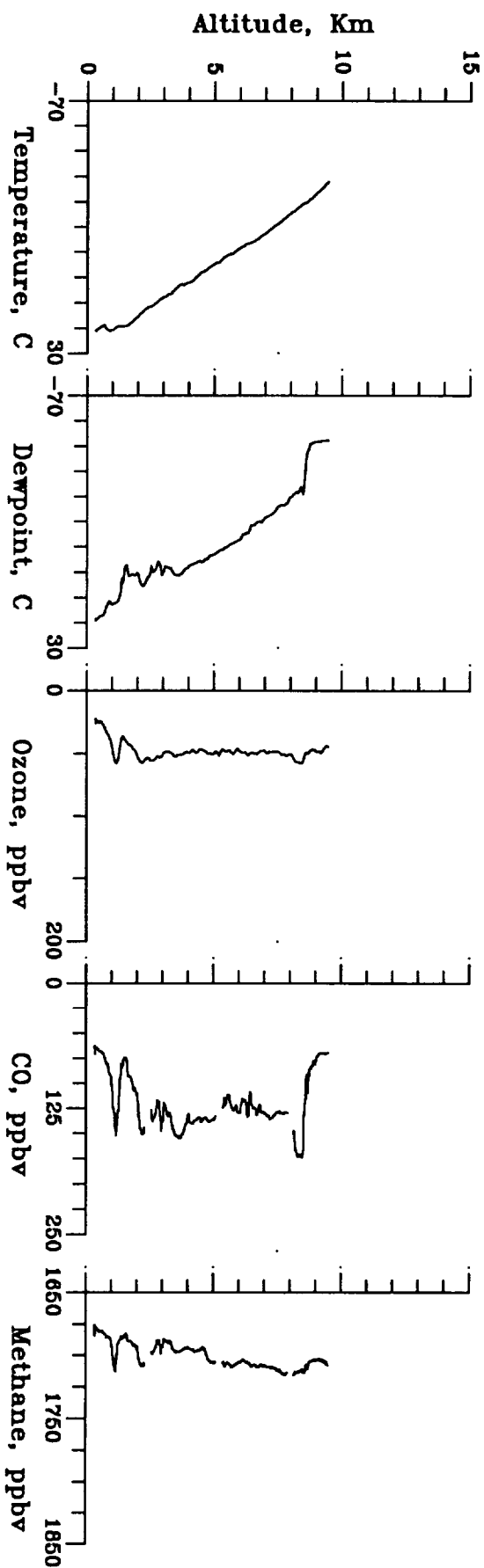
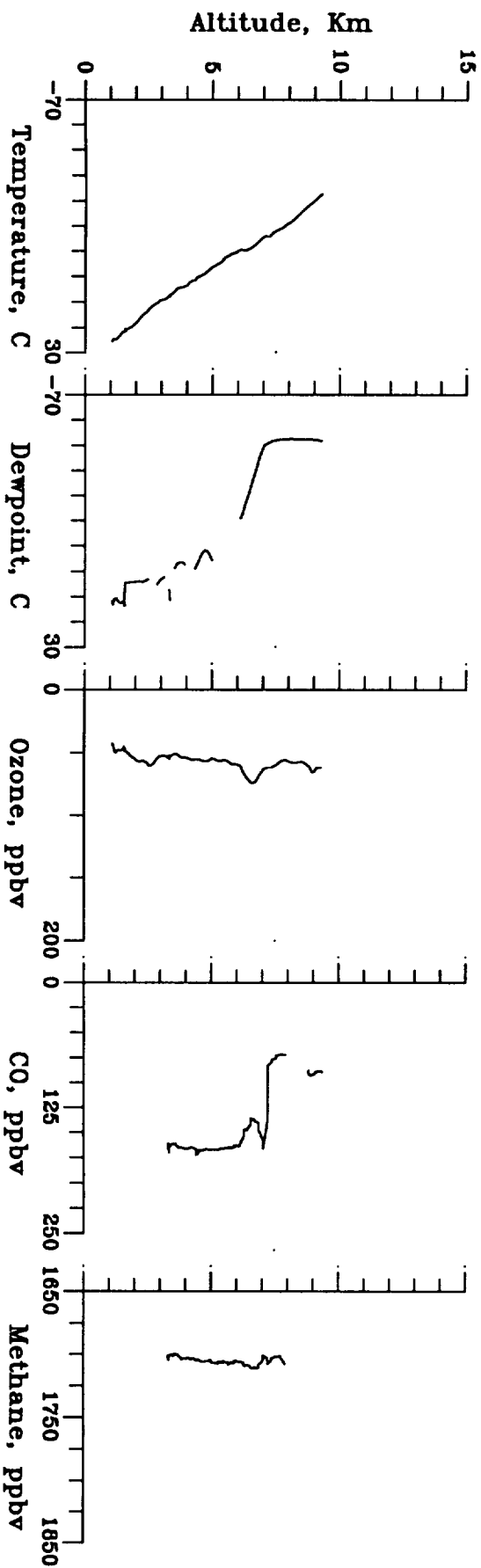


Figure A5.6

TRACE (A) ATLANTIC MISSION: FLIGHT 5 PROFILE AT 1600 GMT



TRACE (A) ATLANTIC MISSION: FLIGHT 5 PROFILE AT 1845 GMT



TRACE-A ATLANTIC MISSION: FLIGHT 6

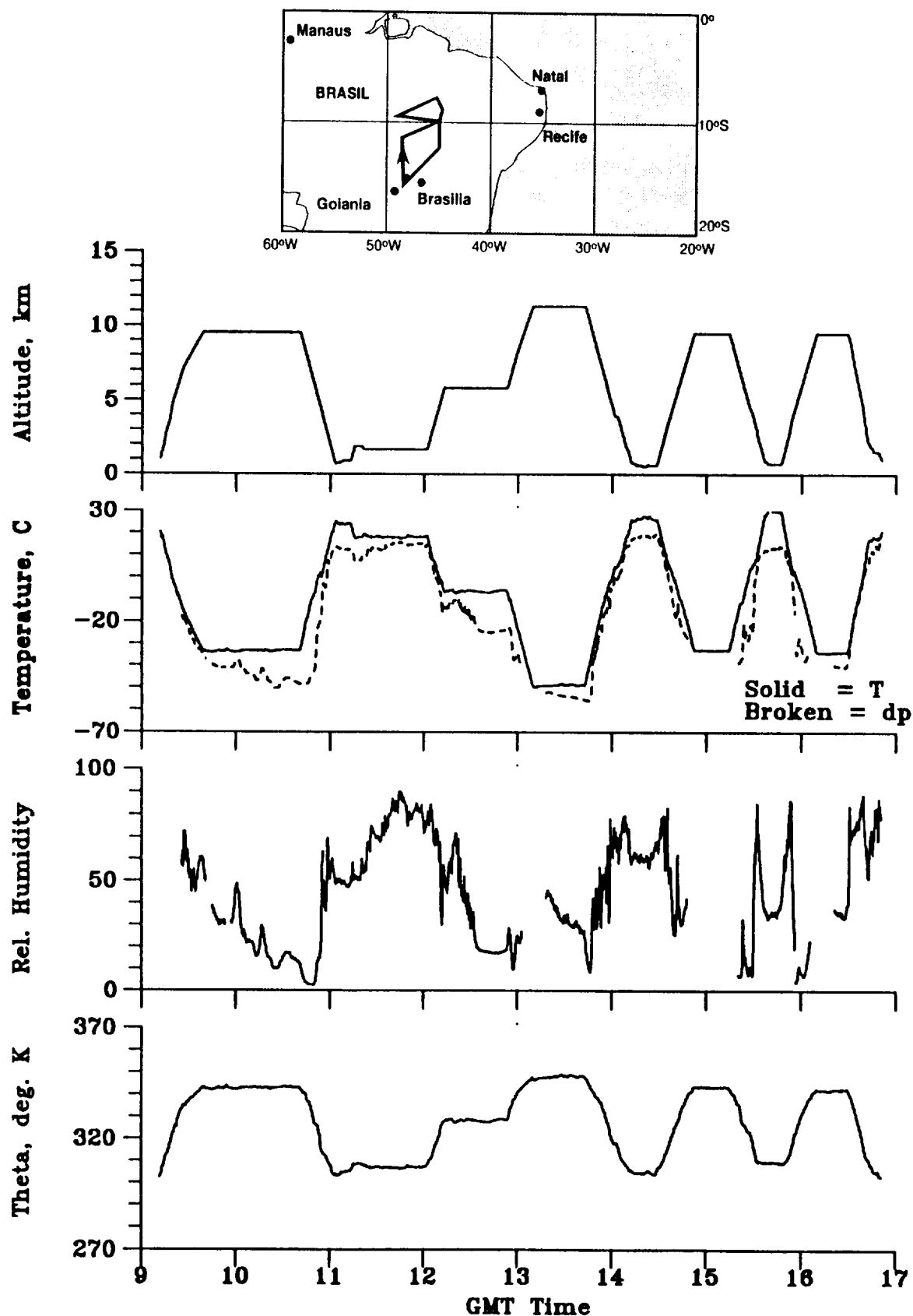


Figure A6.1

TRACE-A ATLANTIC MISSION: FLIGHT 6

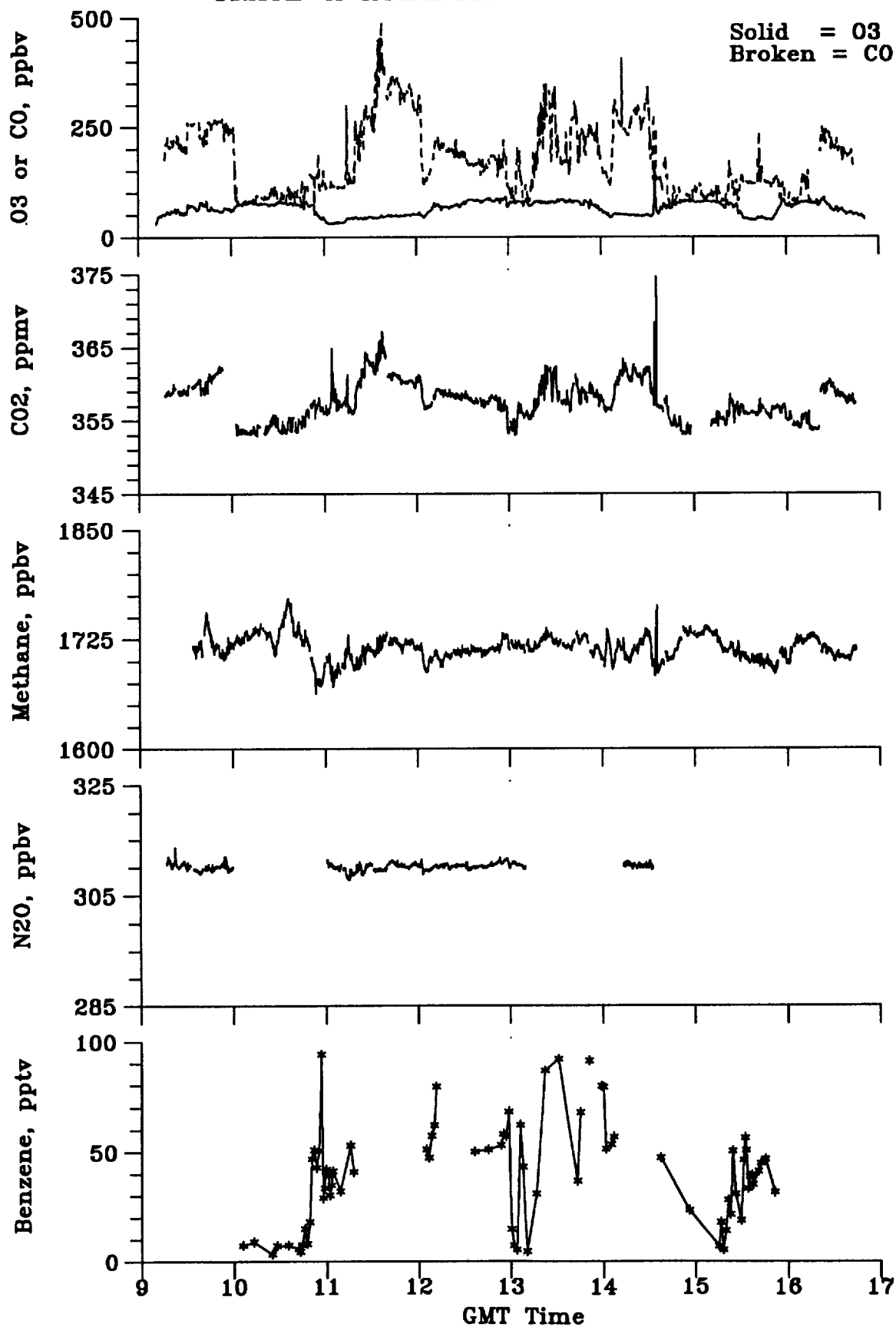


Figure A6.2

TRACE-A ATLANTIC MISSION: FLIGHT 6

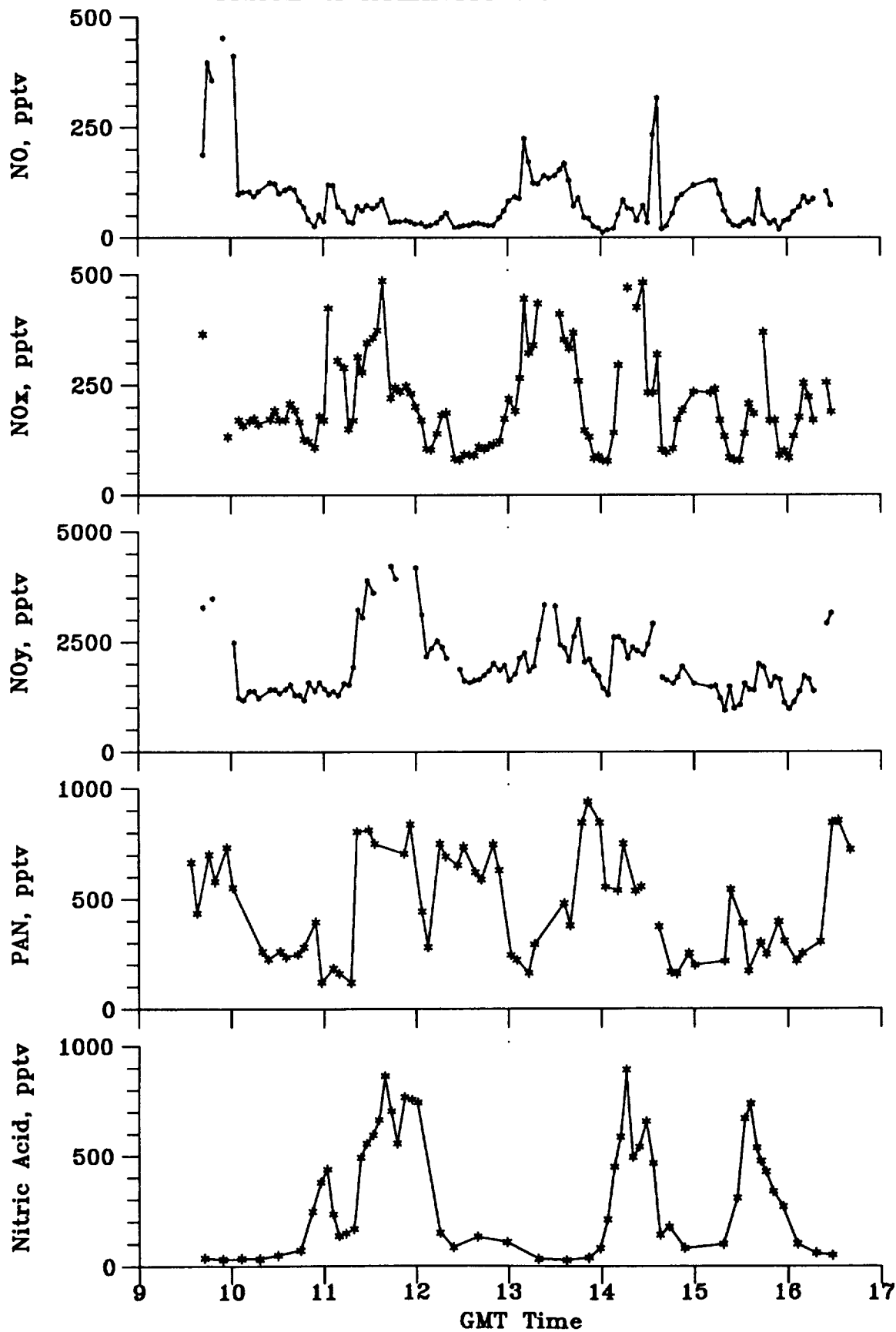


Figure A6.3

TRACE-A ATLANTIC MISSION: FLIGHT 6

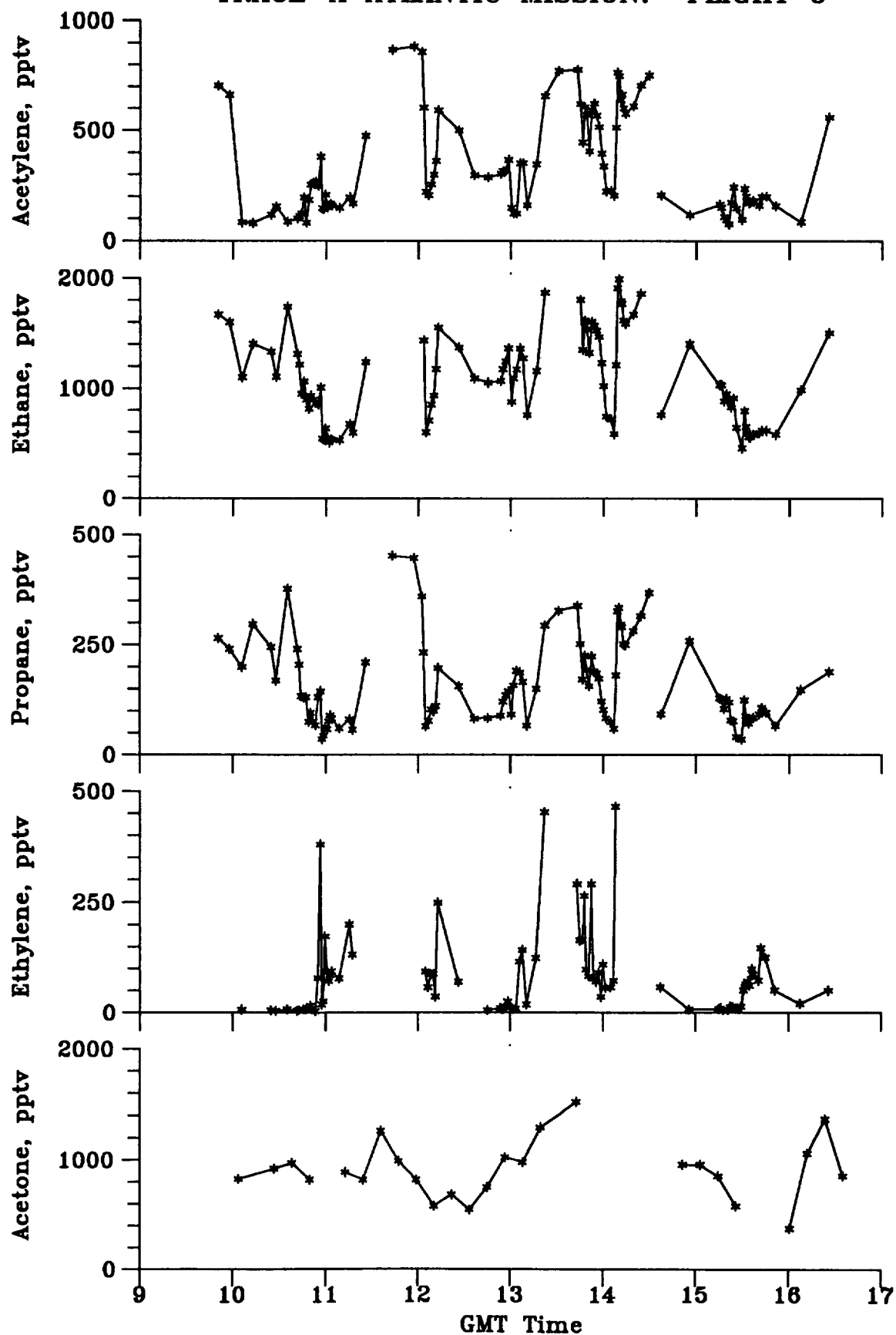


Figure A6.4

TRACE-A ATLANTIC MISSION: FLIGHT 6

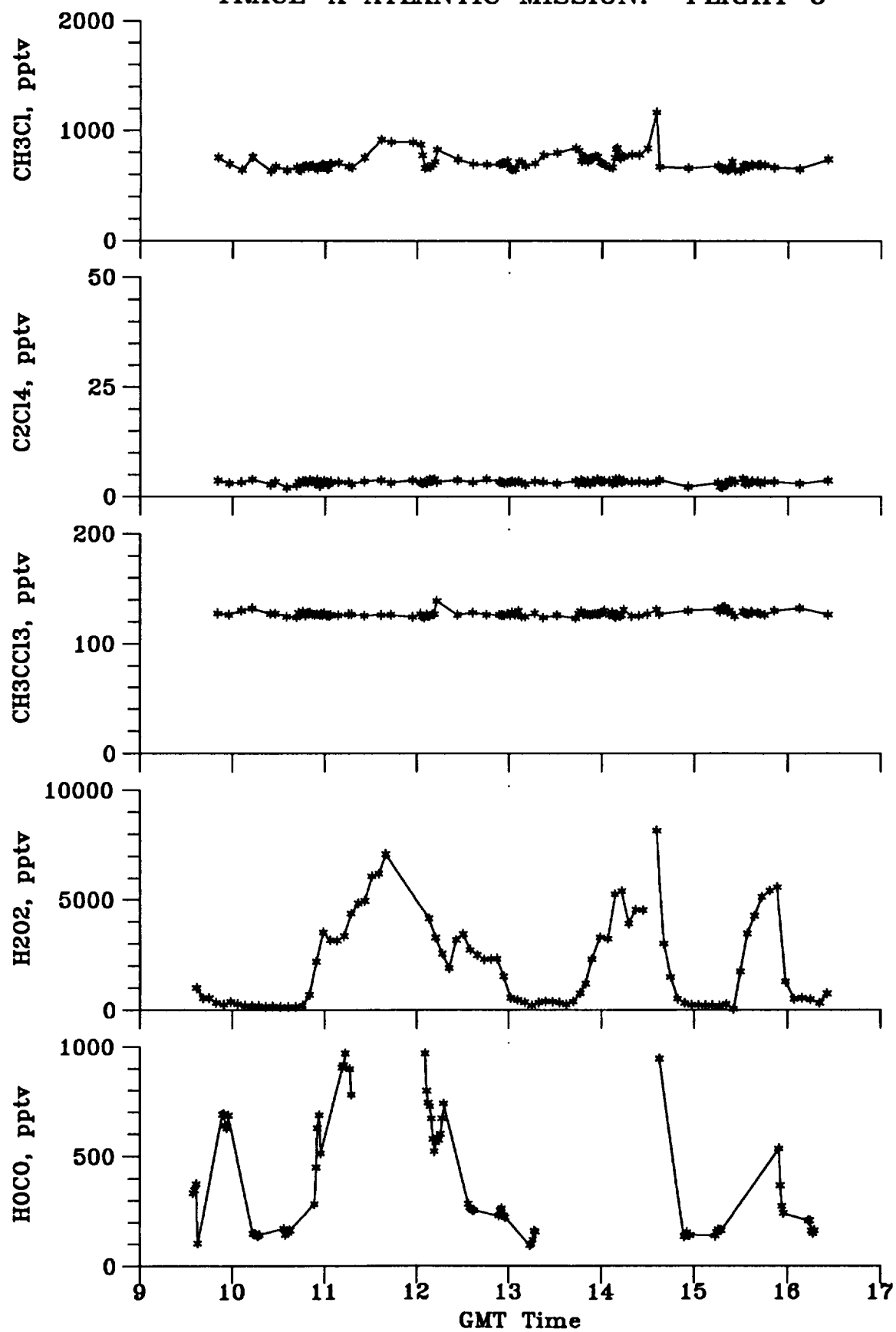


Figure A6.5

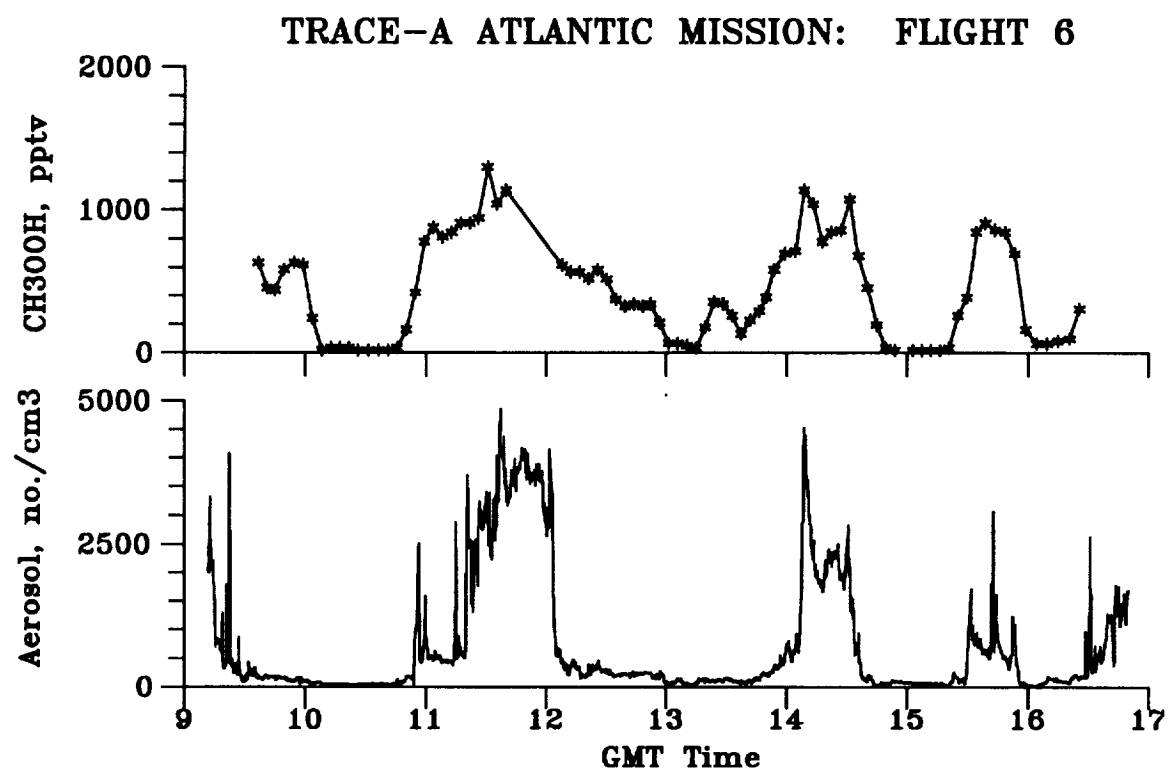
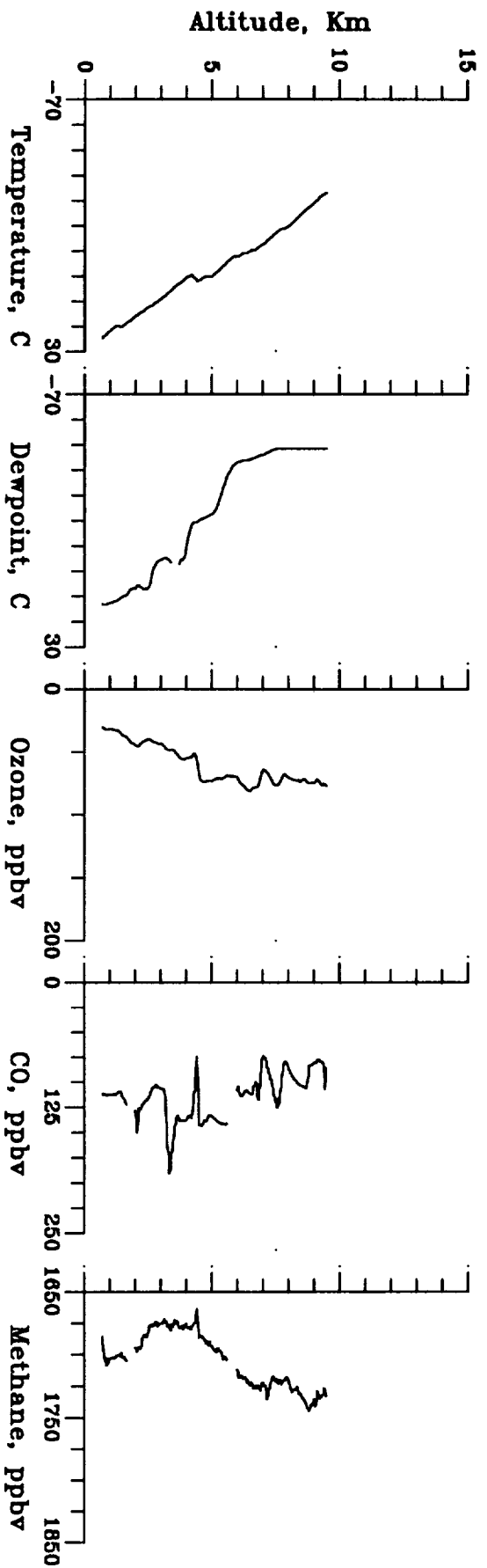
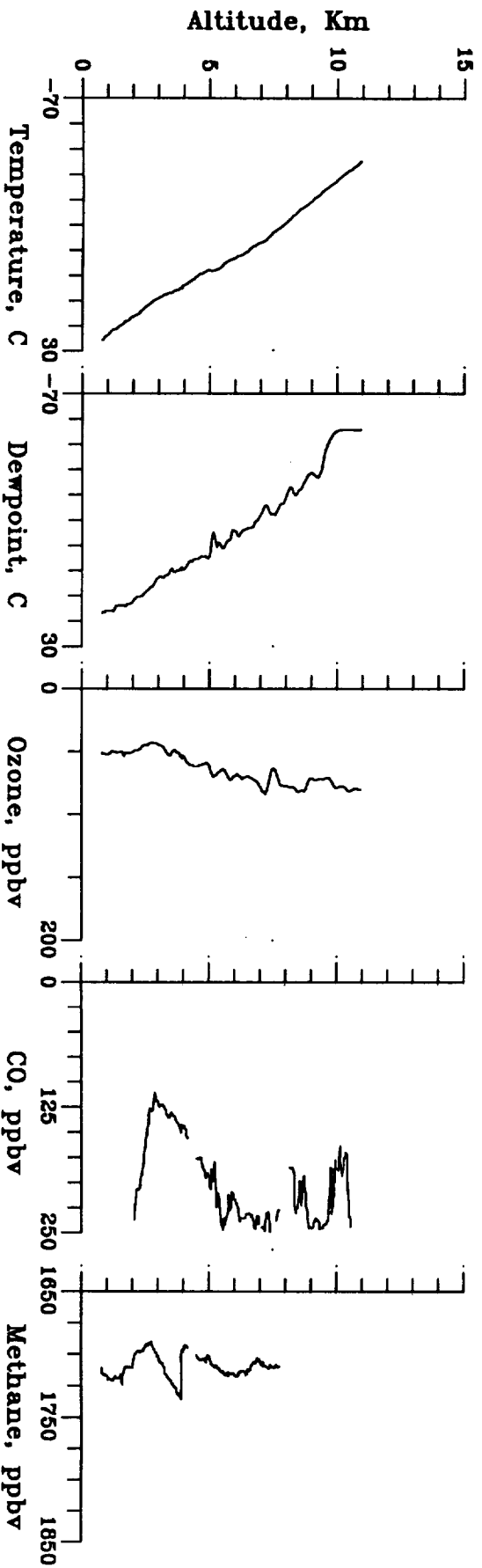


Figure A6.6

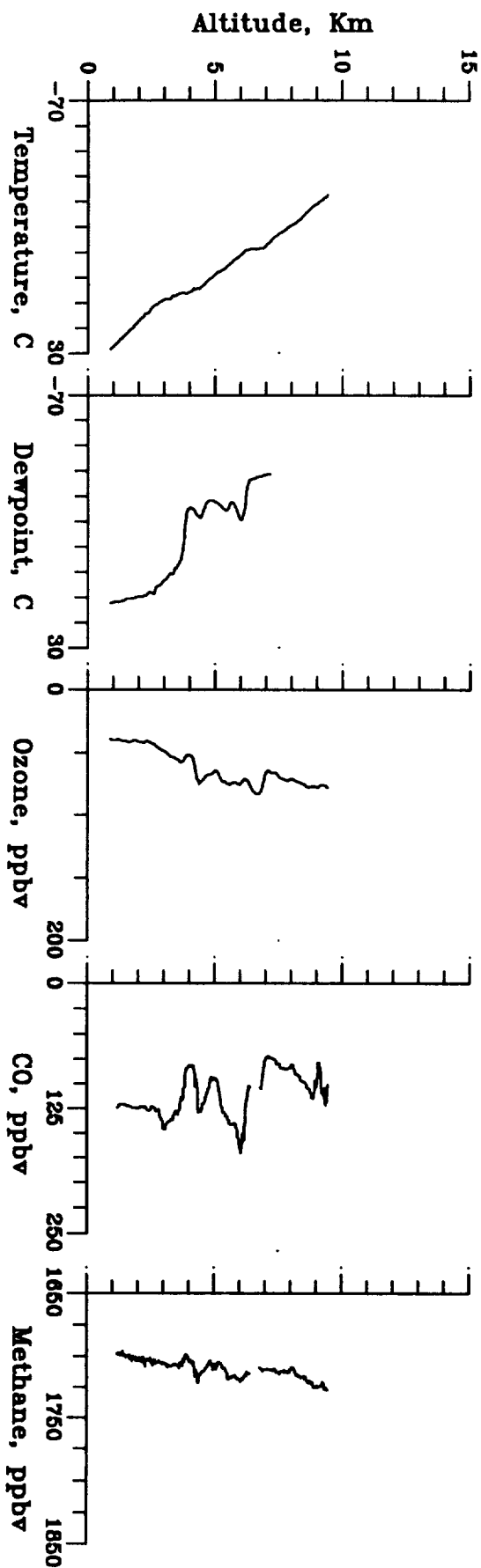
TRACE (A) ATLANTIC MISSION: FLIGHT 6 PROFILE AT 1100 GMT



TRACE (A) ATLANTIC MISSION: FLIGHT 6 PROFILE AT 1400 GMT

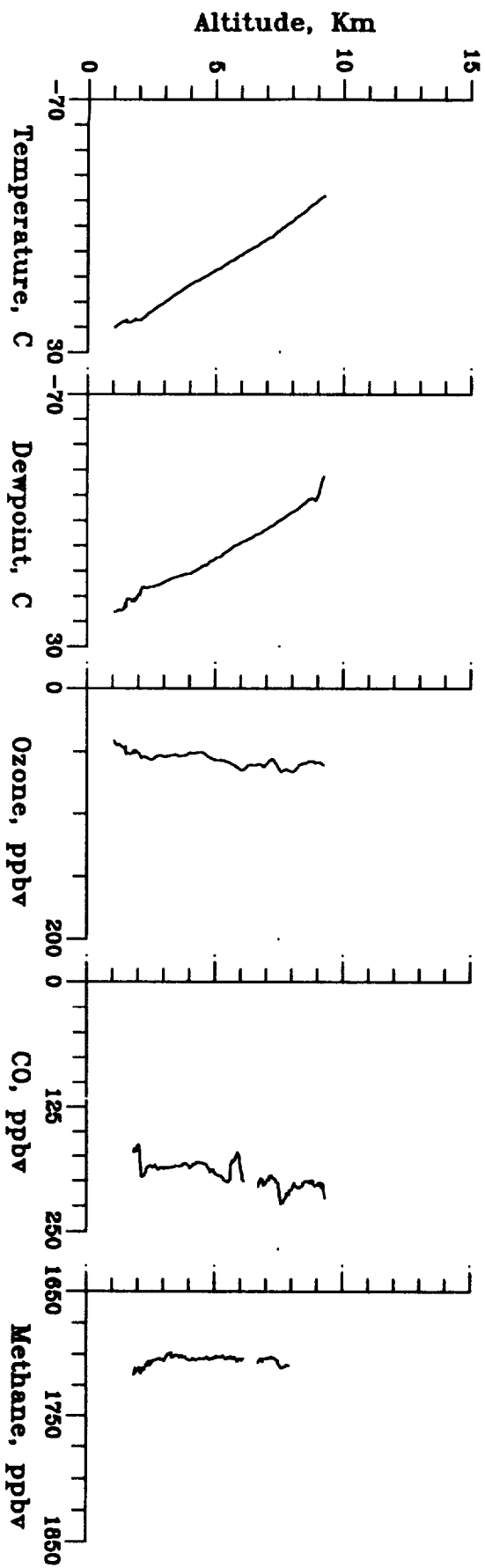


TRACE (A) ATLANTIC MISSION: FLIGHT 6 PROFILE AT 1530 GMT



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TRACE (A) ATLANTIC MISSION: FLIGHT 6 PROFILE AT 1645 GMT



TRACE-A ATLANTIC MISSION: FLIGHT 7

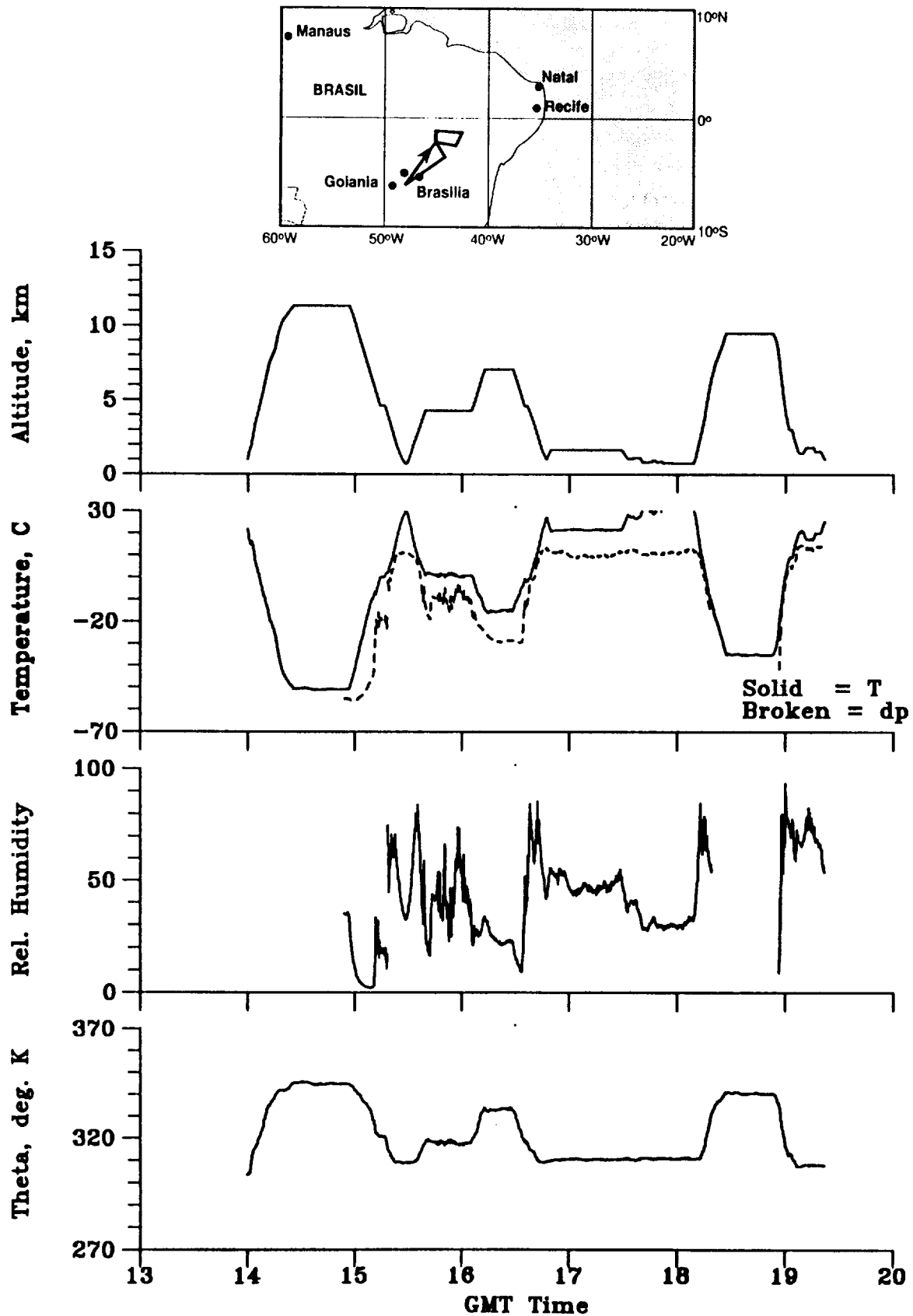


Figure A7.1

TRACE-A ATLANTIC MISSION: FLIGHT 7

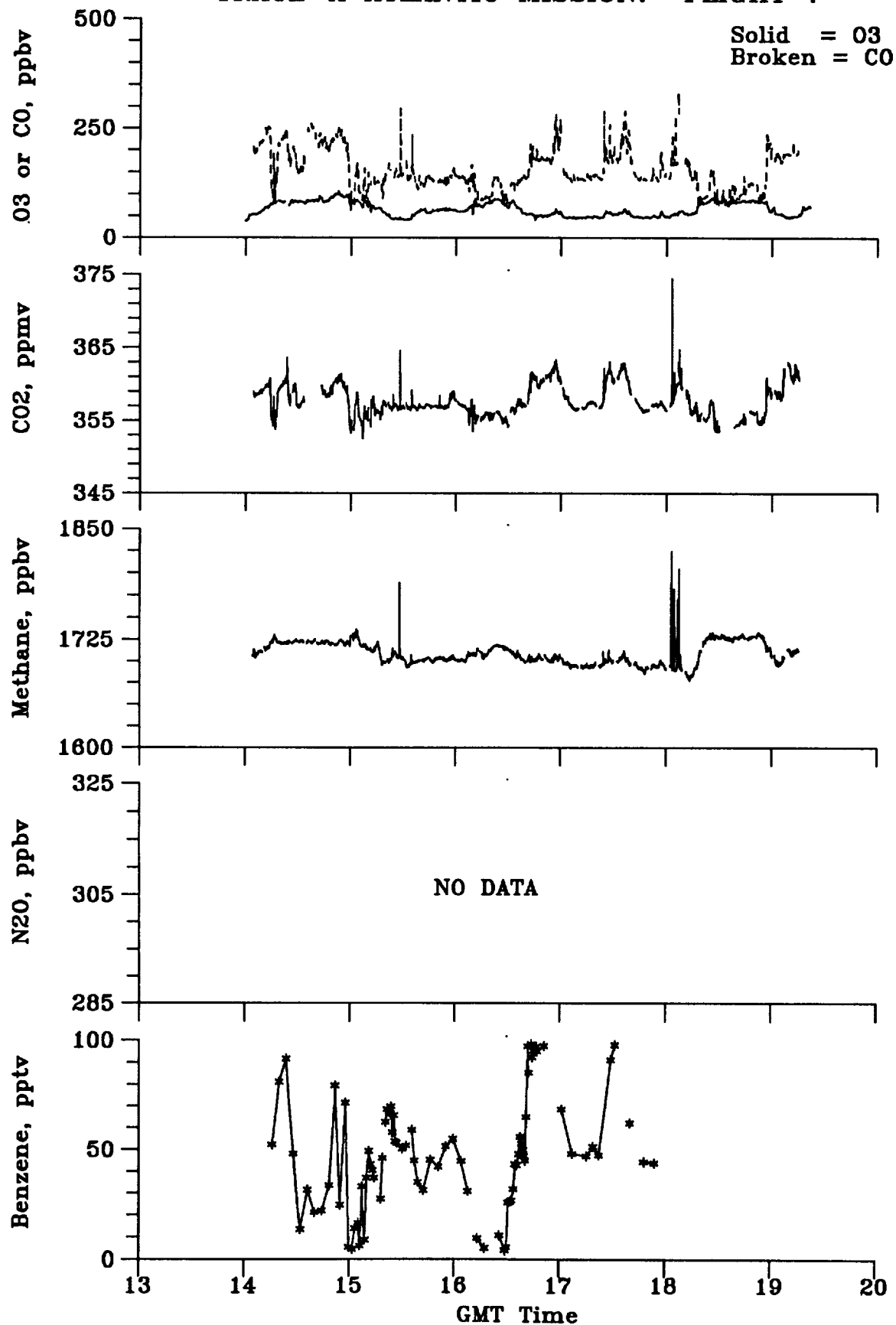


Figure A7.2

TRACE-A ATLANTIC MISSION: FLIGHT 7

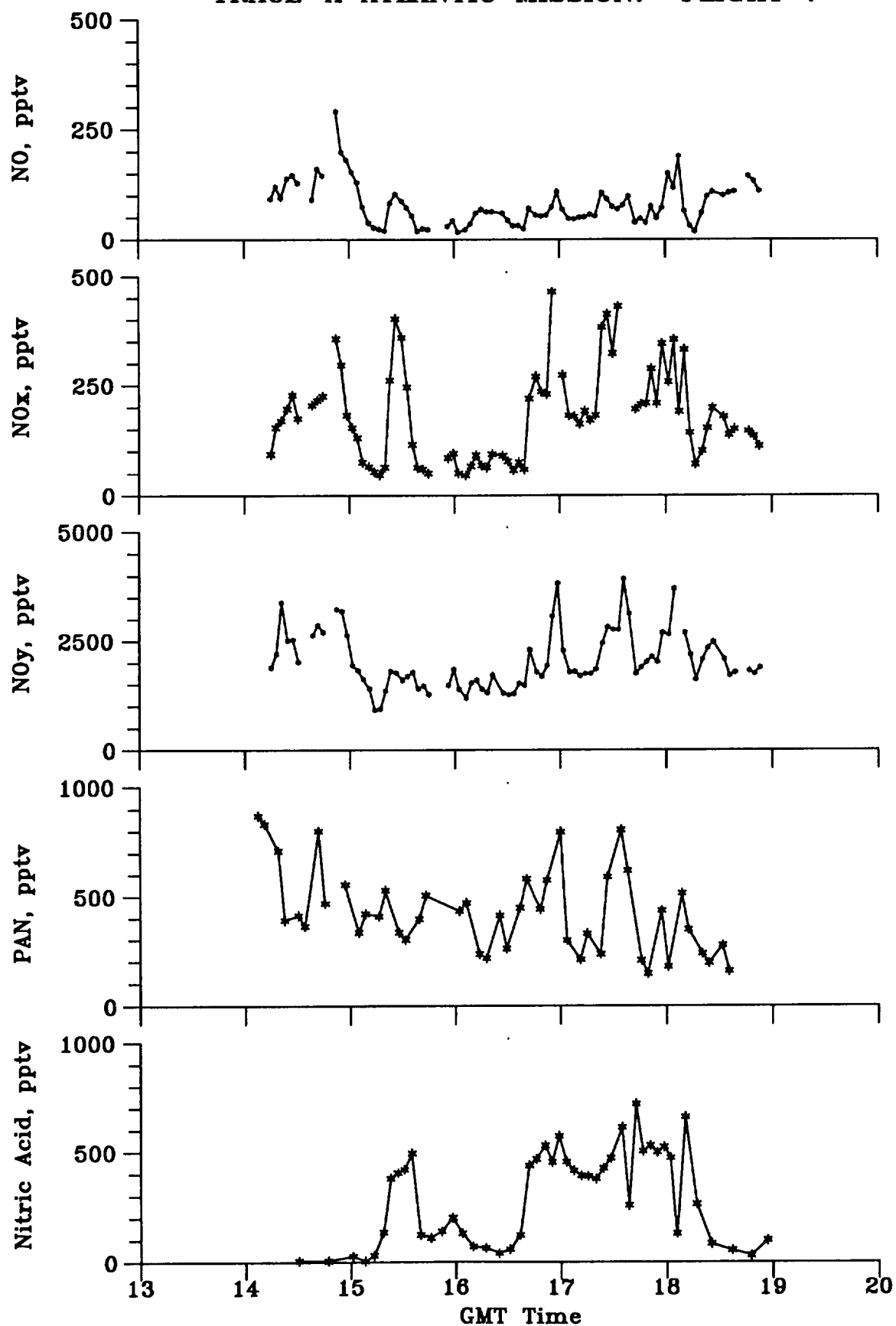


Figure A7.3

TRACE-A ATLANTIC MISSION: FLIGHT 7

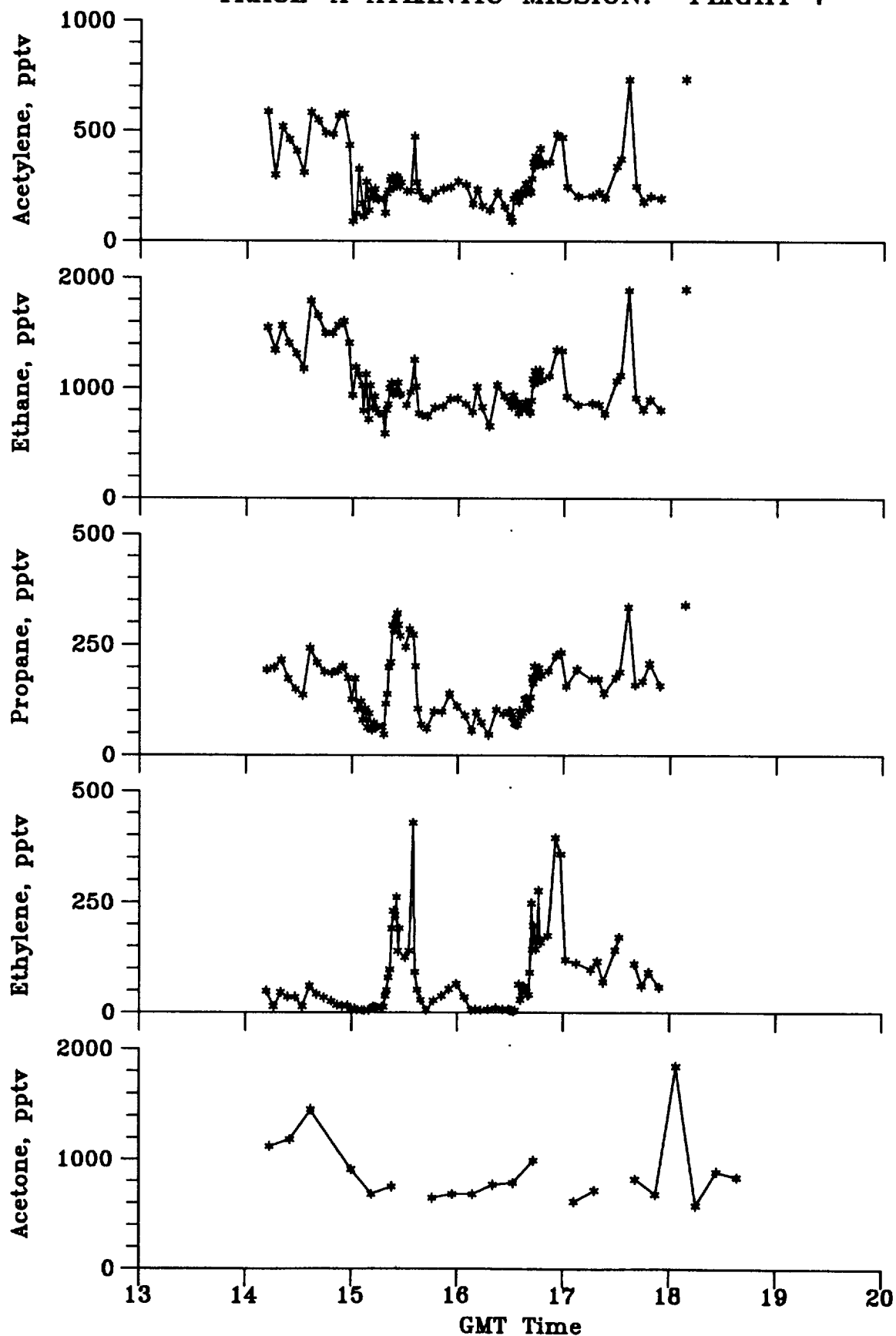


Figure A7.4

TRACE-A ATLANTIC MISSION: FLIGHT 7

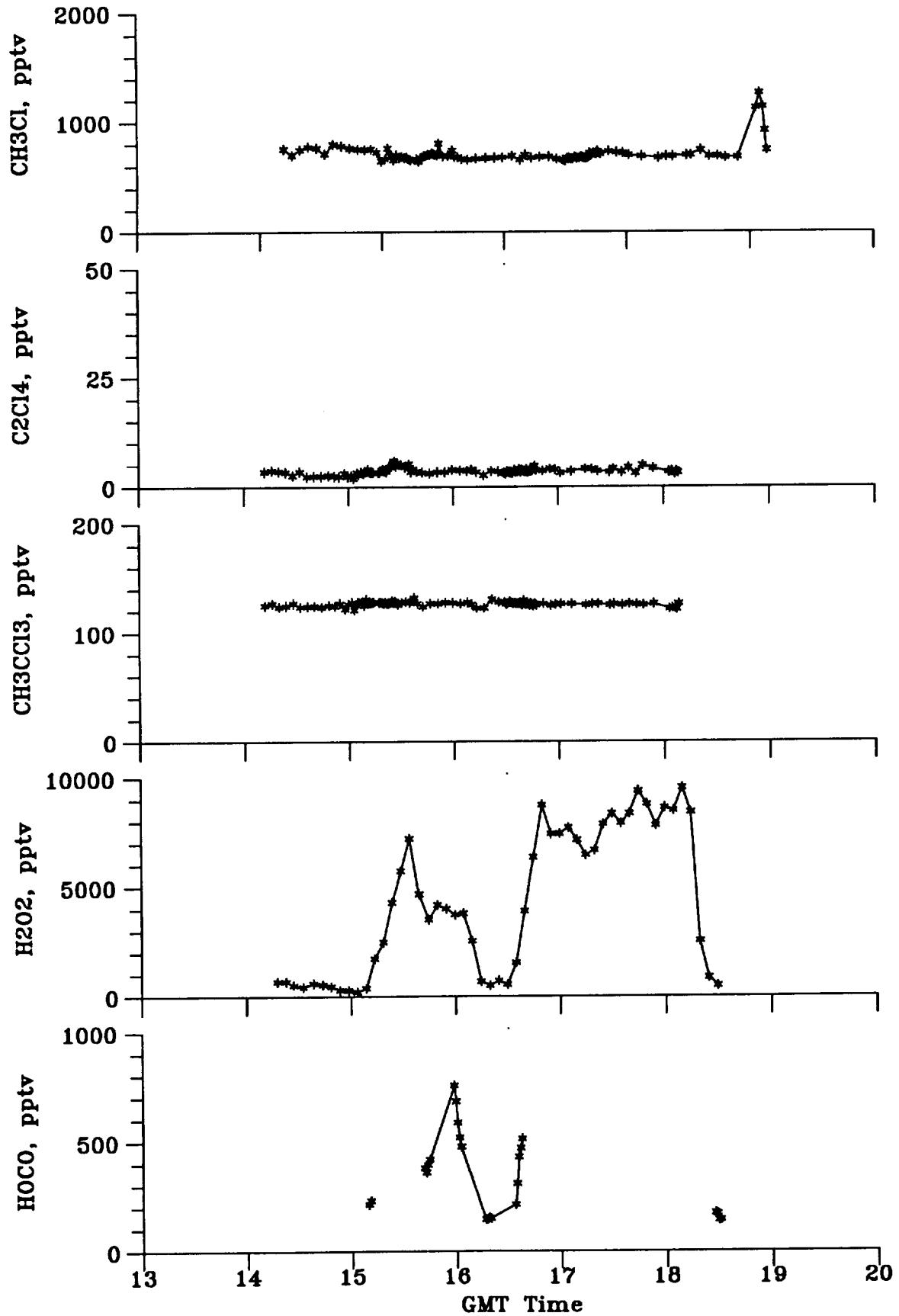


Figure A7.5

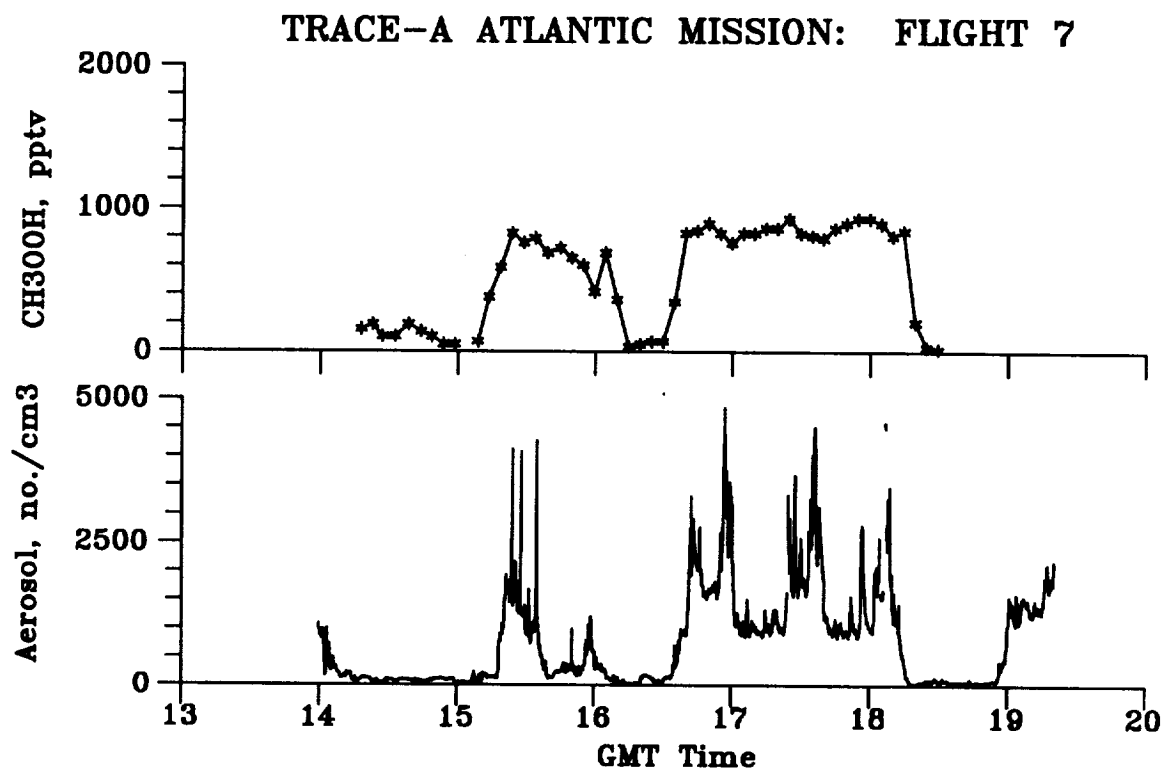
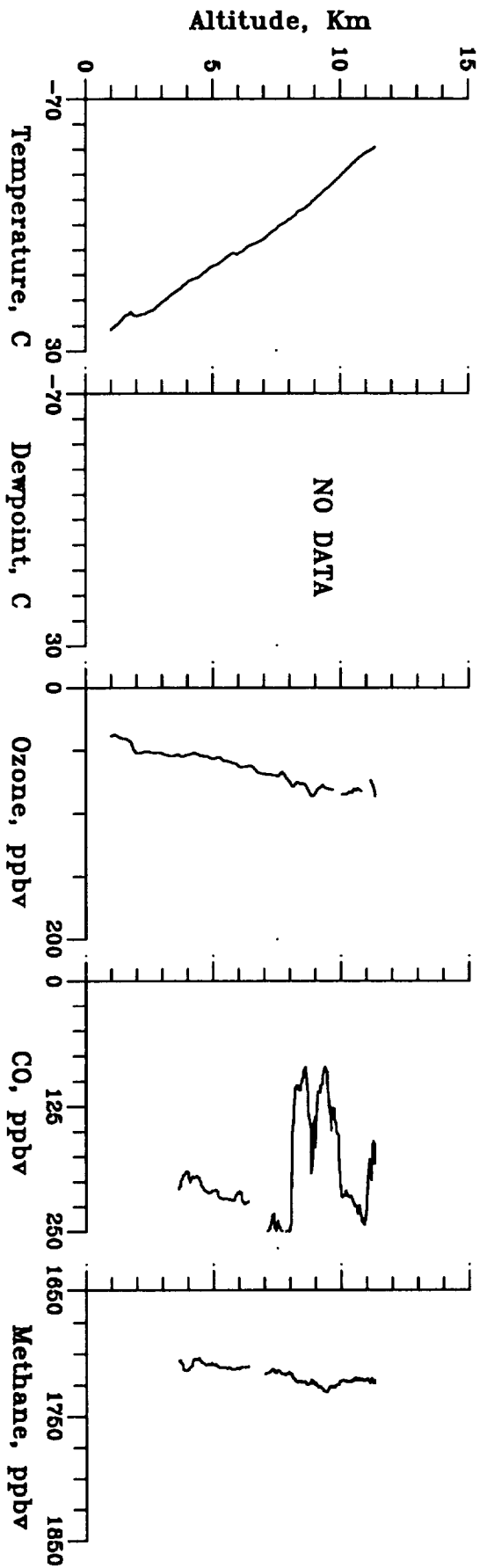
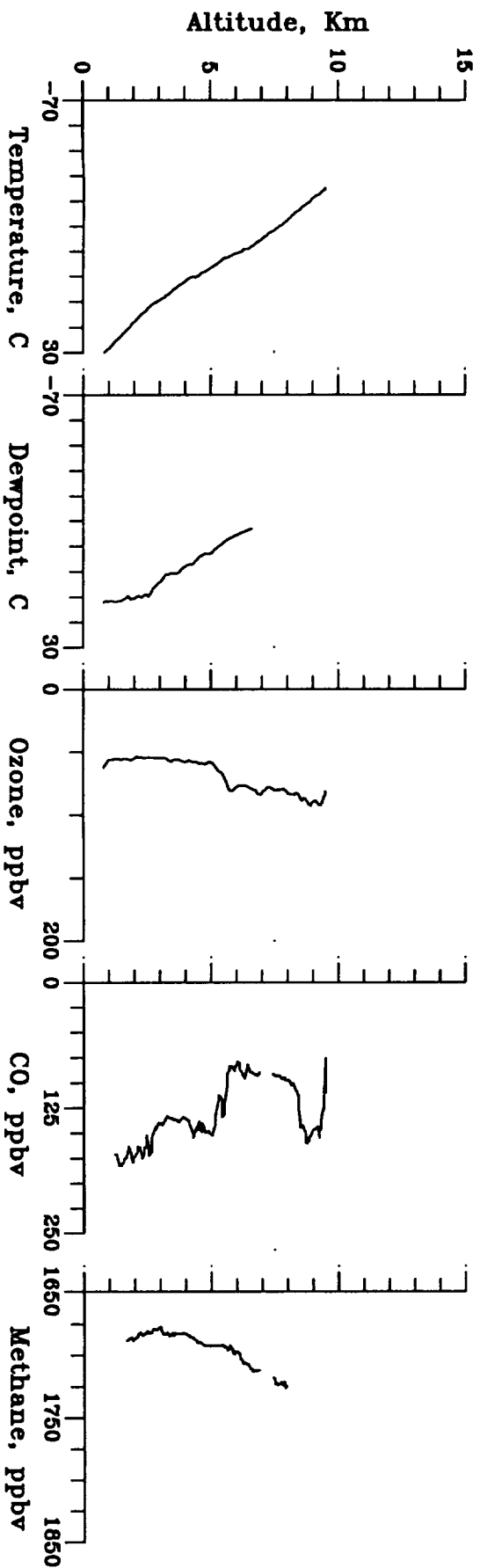


Figure A7.6

TRACE (A) ATLANTIC MISSION: FLIGHT 7 PROFILE AT 1415 GMT



TRACE (A) ATLANTIC MISSION: FLIGHT 7 PROFILE AT 1815 GMT



TRACE-A ATLANTIC MISSION: FLIGHT 8

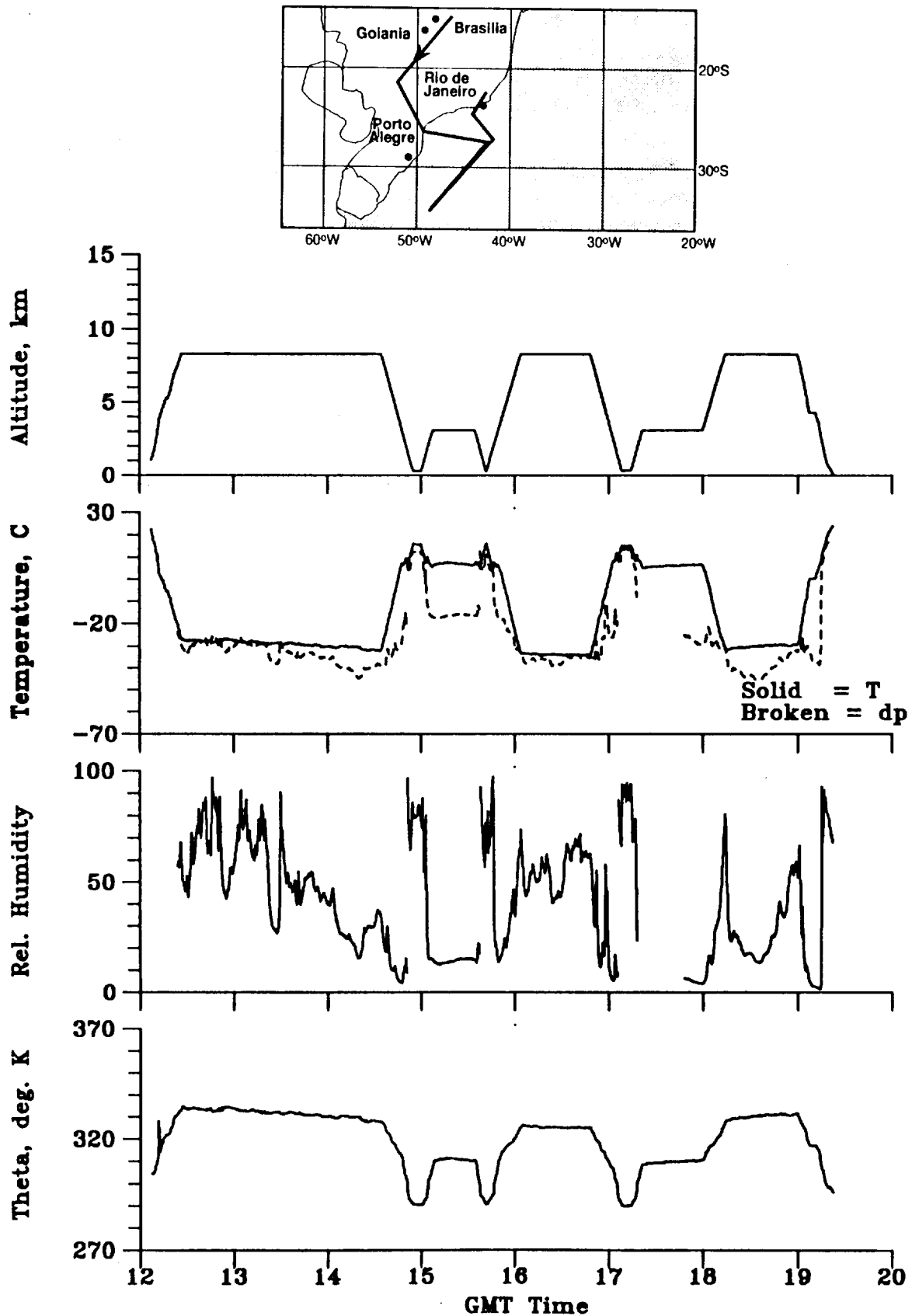


Figure AB.1

TRACE-A ATLANTIC MISSION: FLIGHT 8

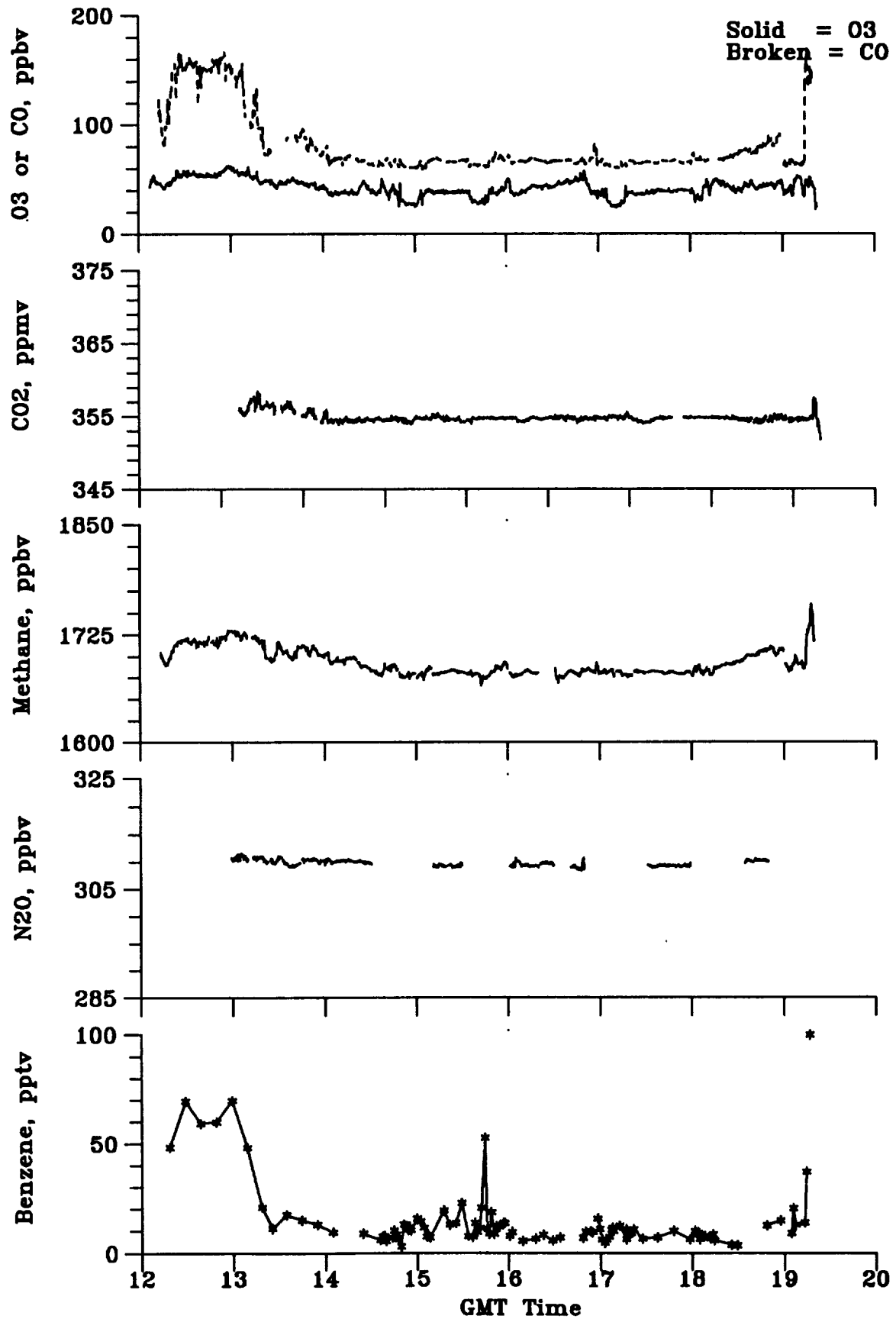


Figure A8.2

TRACE-A ATLANTIC MISSION: FLIGHT 8

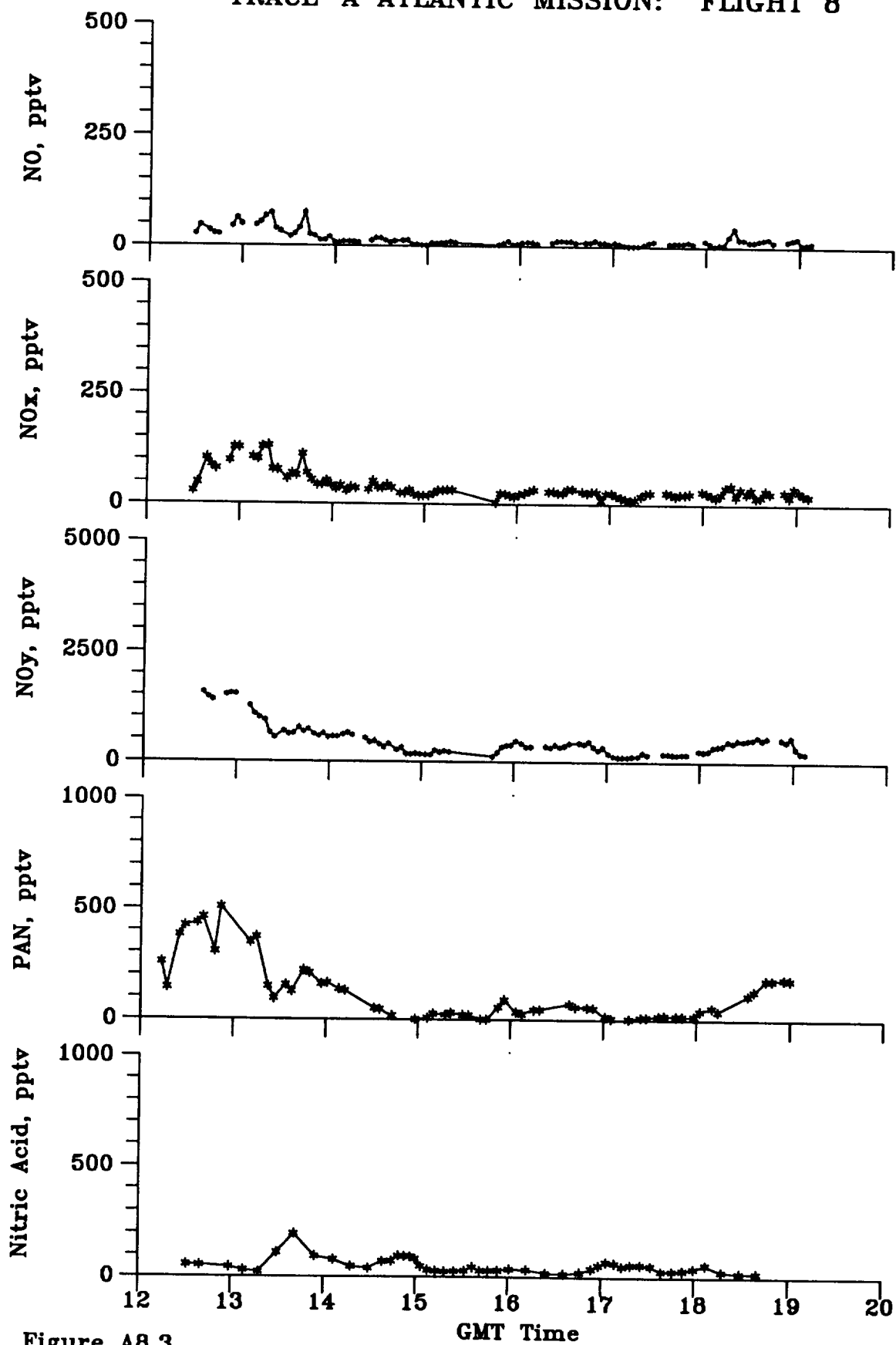


Figure A8.3

TRACE-A ATLANTIC MISSION: FLIGHT 8

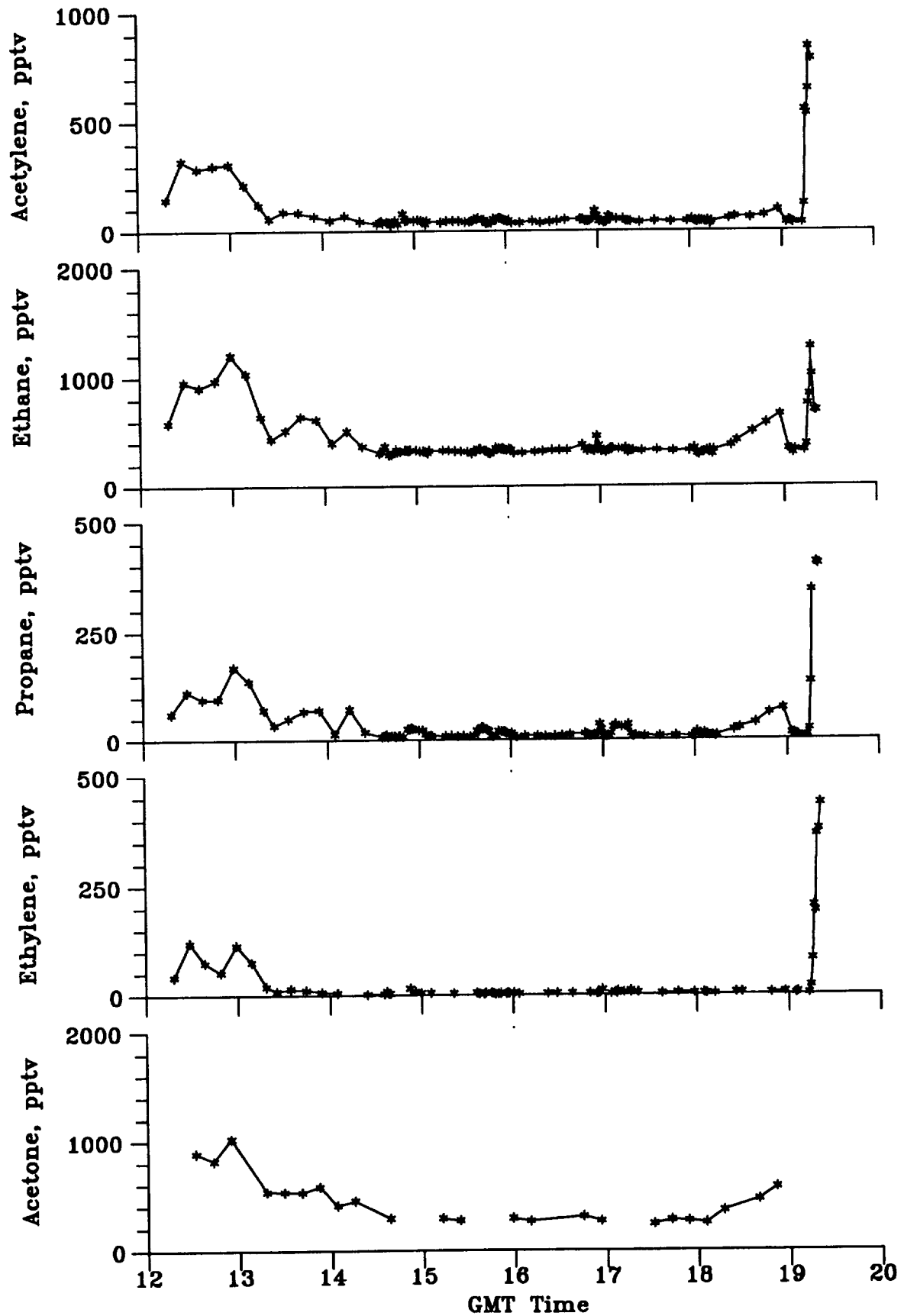


Figure A8.4

TRACE-A ATLANTIC MISSION: FLIGHT 8

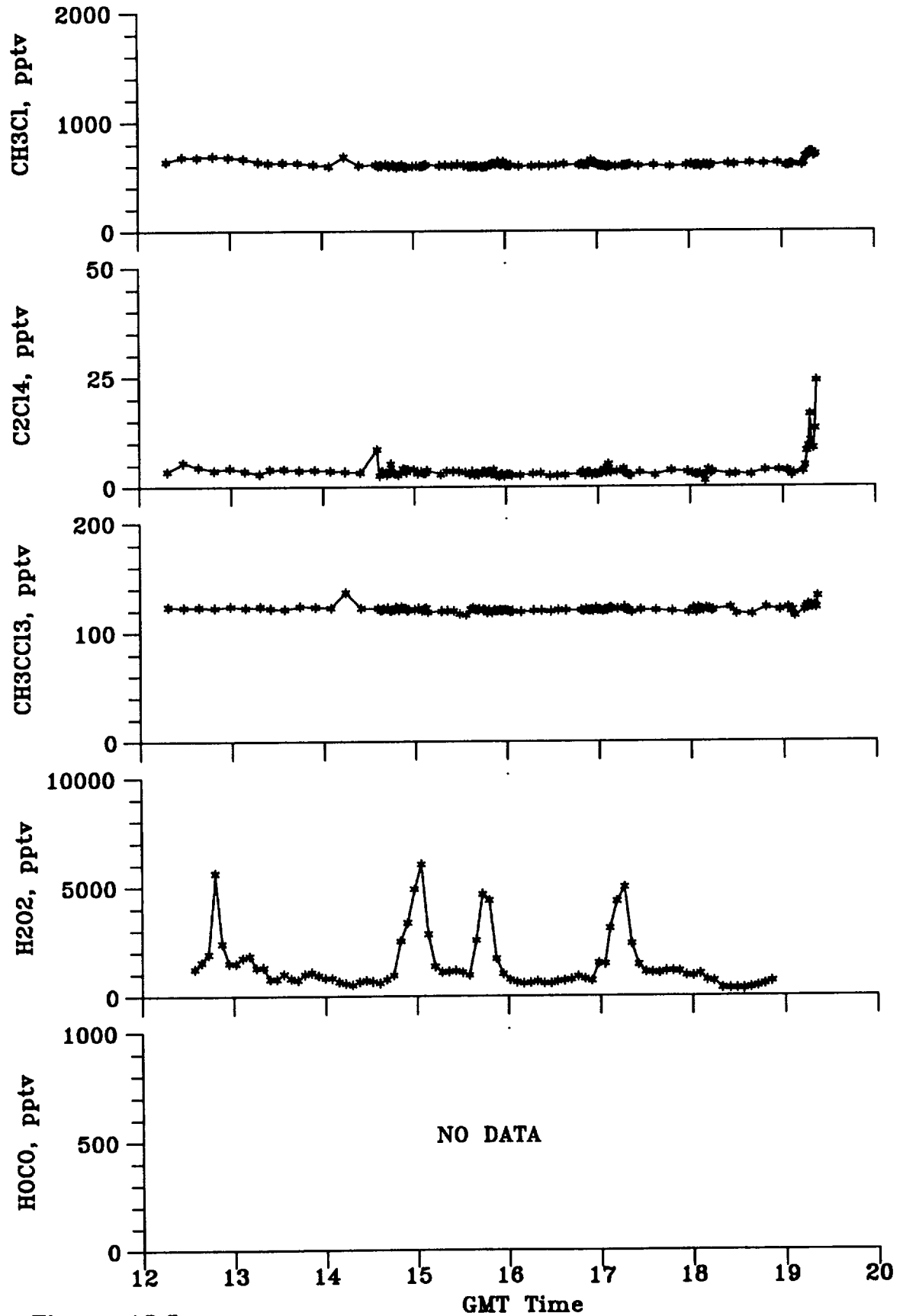


Figure A8.5

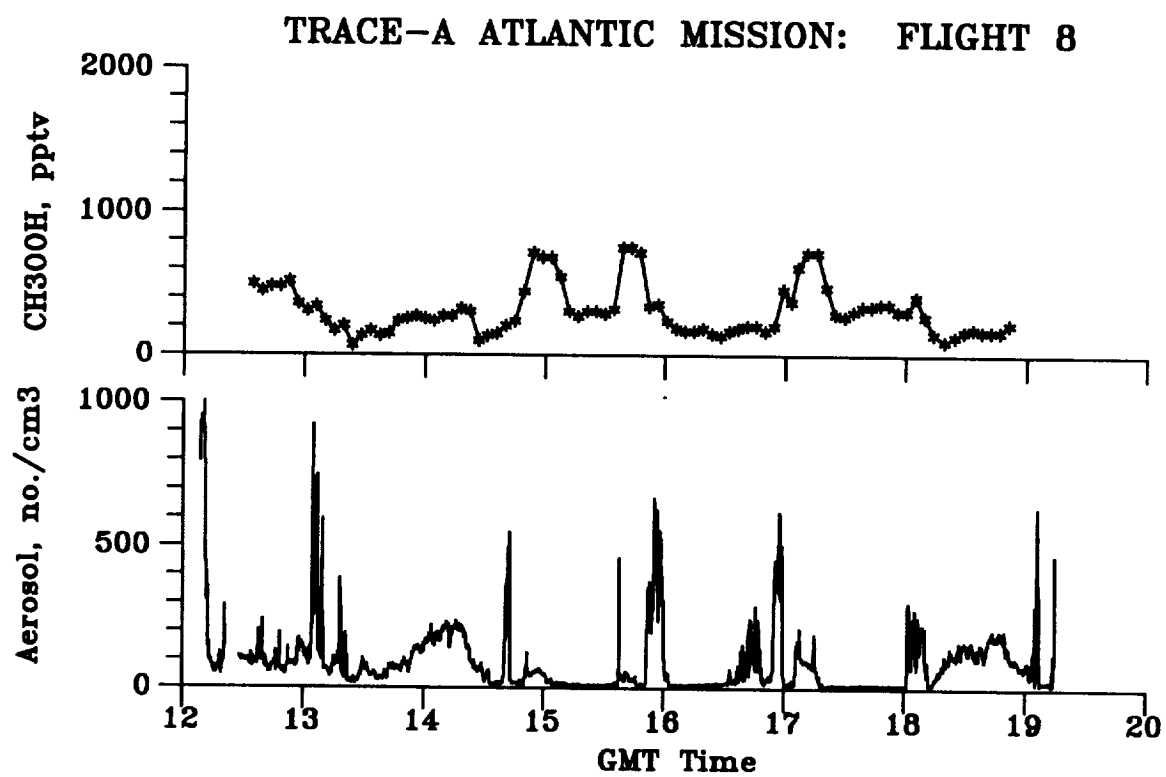
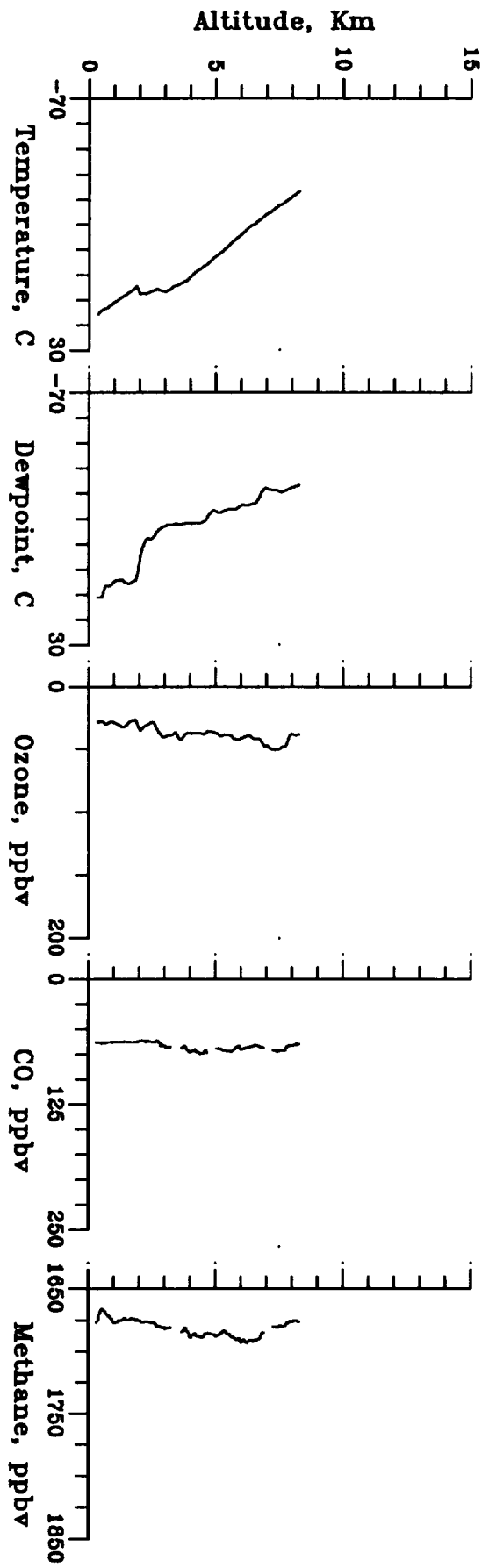


Figure A8.6

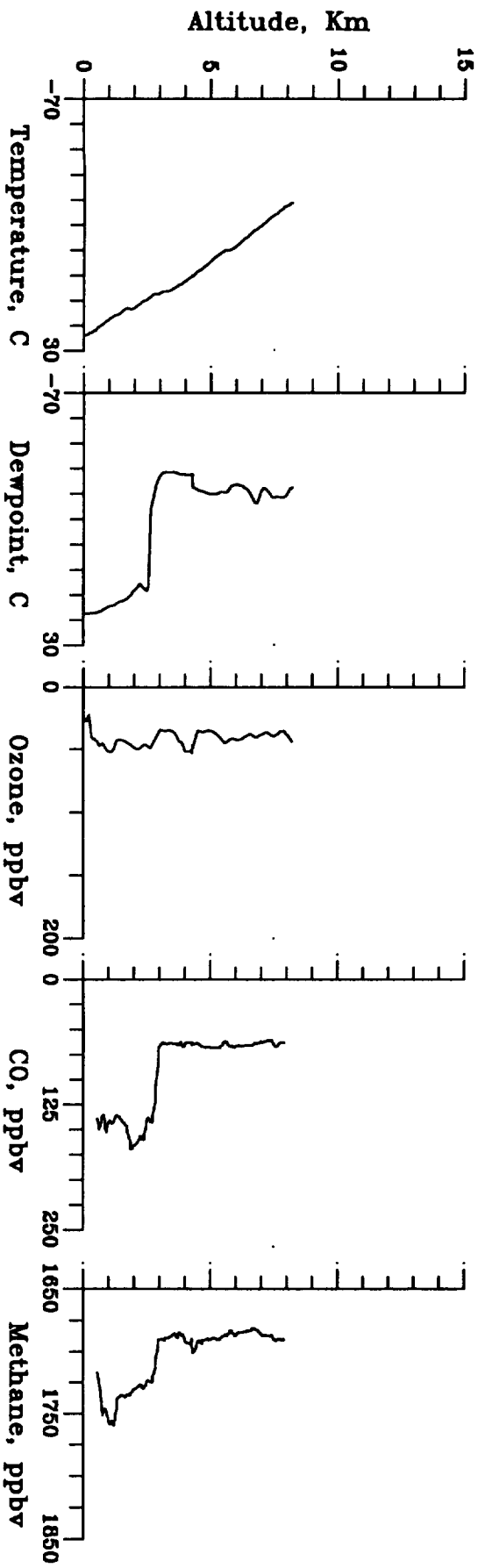
TRACE (A) ATLANTIC MISSION: FLIGHT 8 PROFILE AT 1600 GMT



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Figure A8.7

TRACE (A) ATLANTIC MISSION: FLIGHT 8 PROFILE AT 1915 GMT



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TRACE-A ATLANTIC MISSION: FLIGHT 9

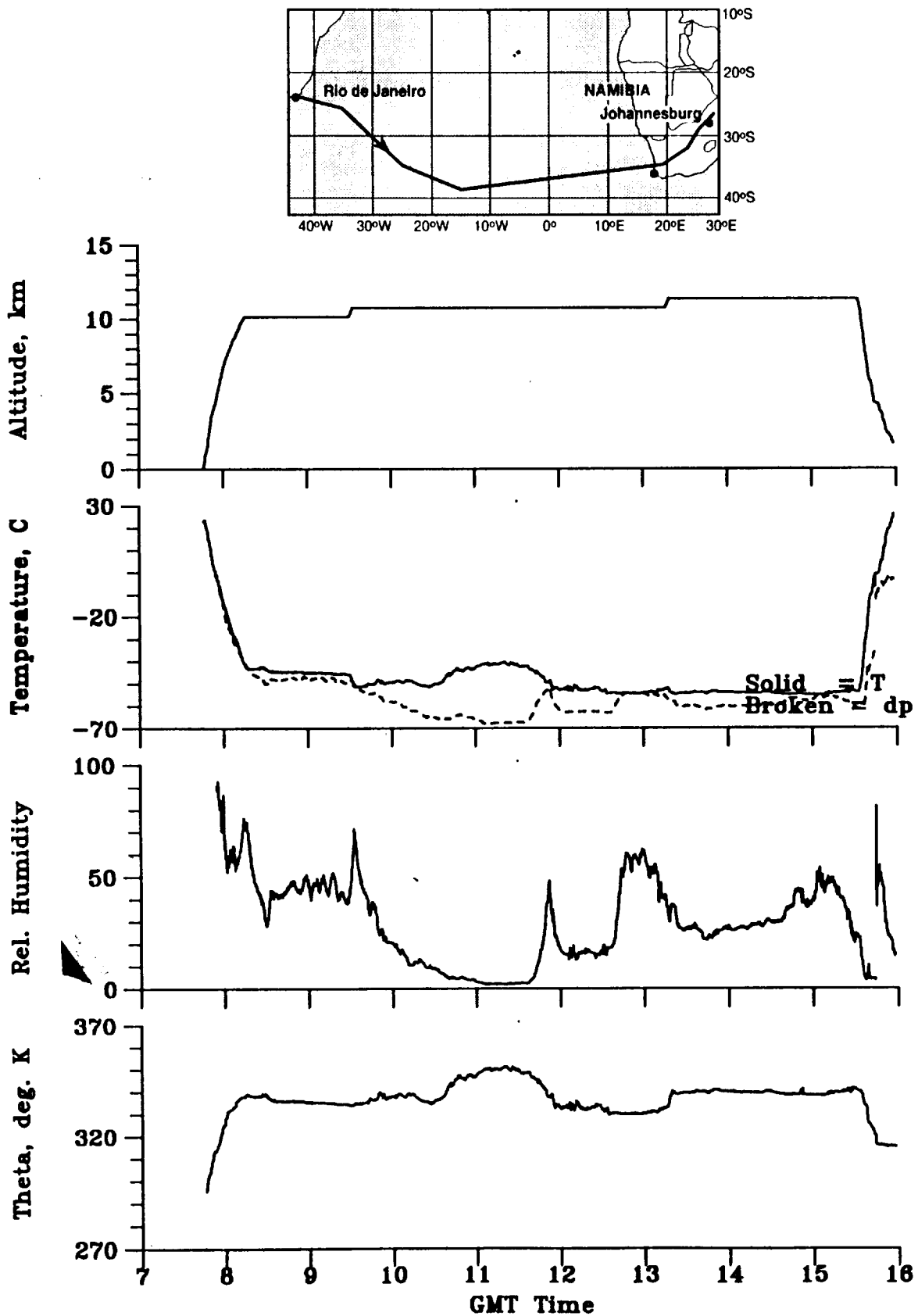


Figure A9.1

TRACE-A ATLANTIC MISSION: FLIGHT 9

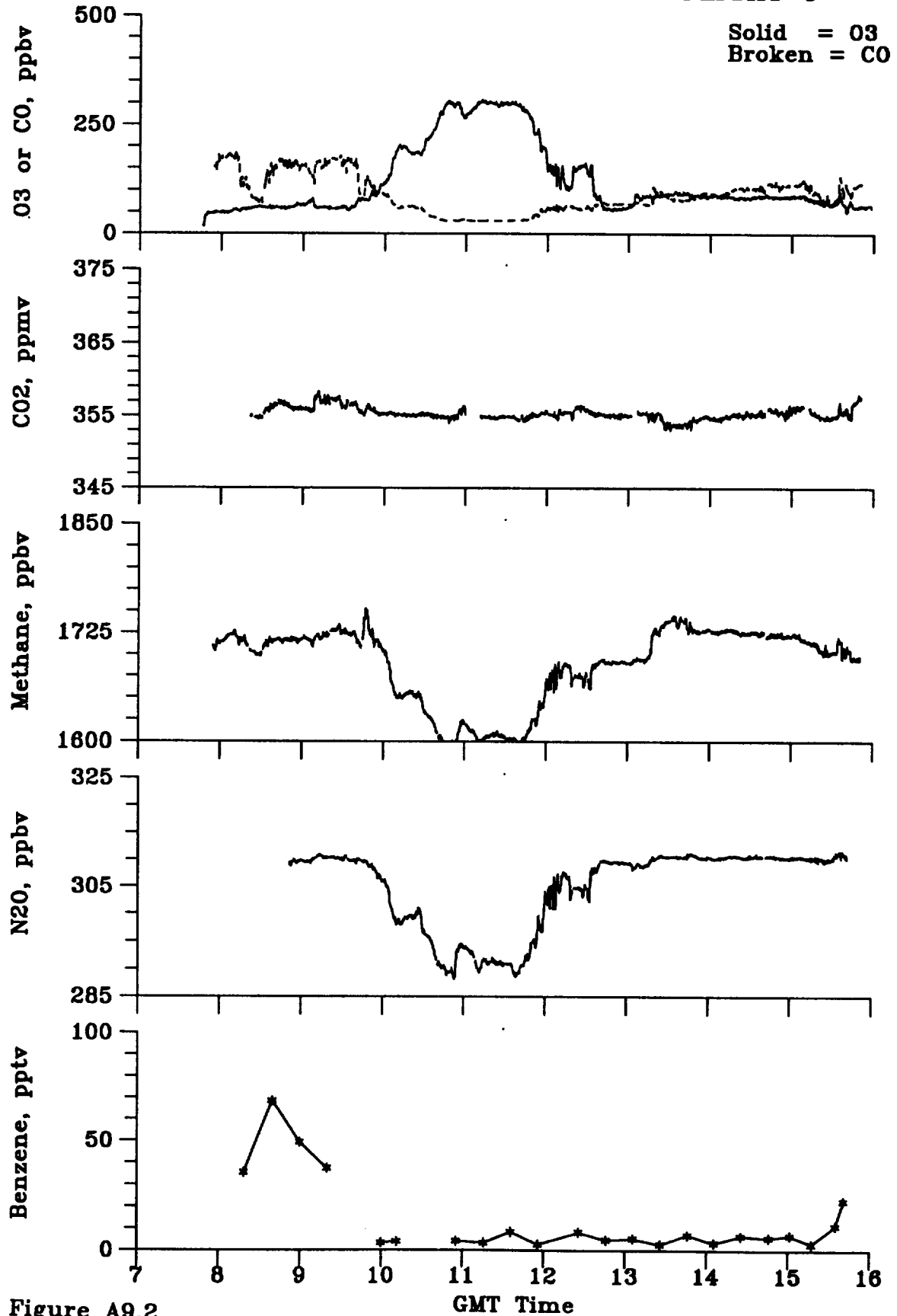


Figure A9.2

TRACE-A ATLANTIC MISSION: FLIGHT 9

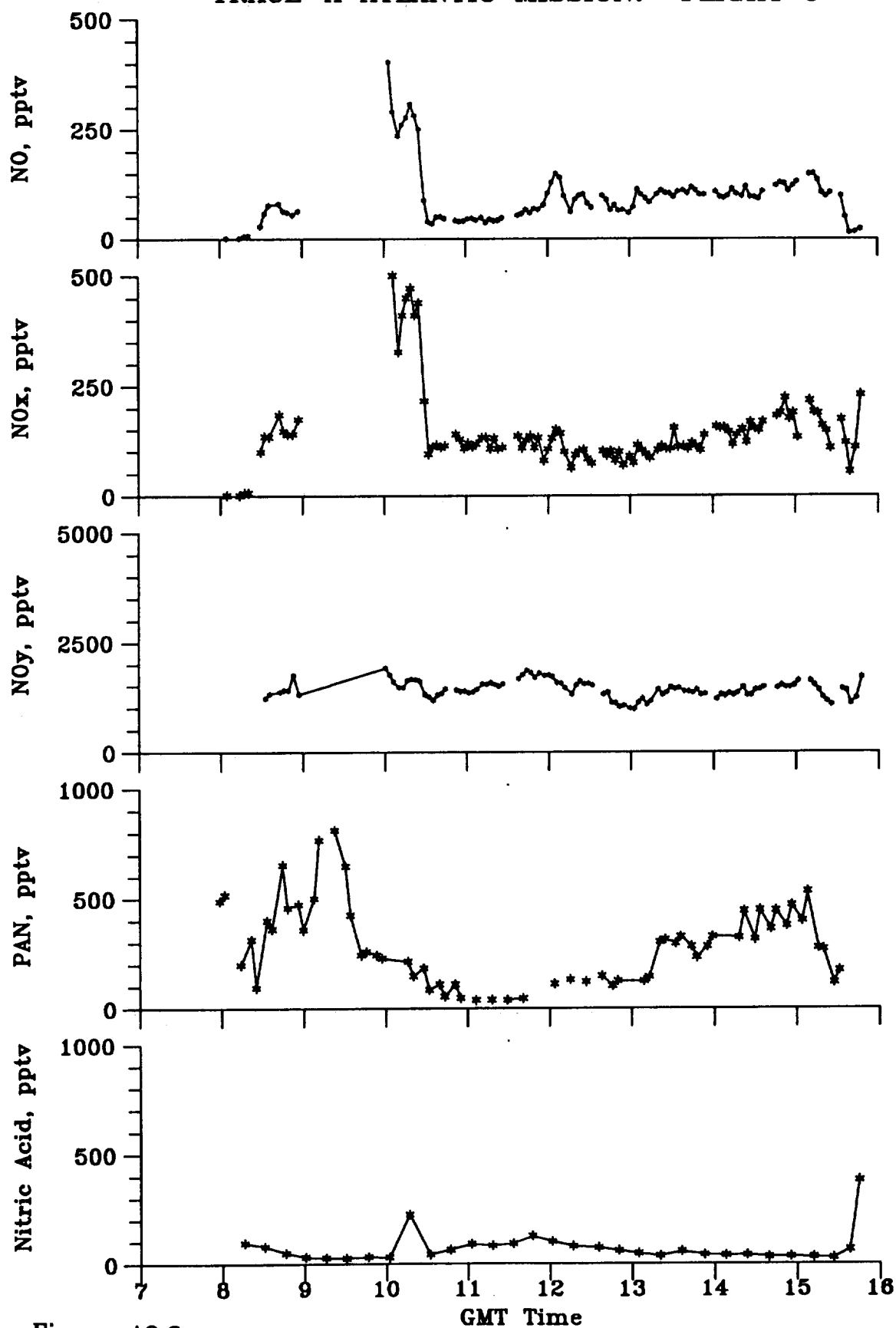


Figure A9.3

TRACE-A ATLANTIC MISSION: FLIGHT 9

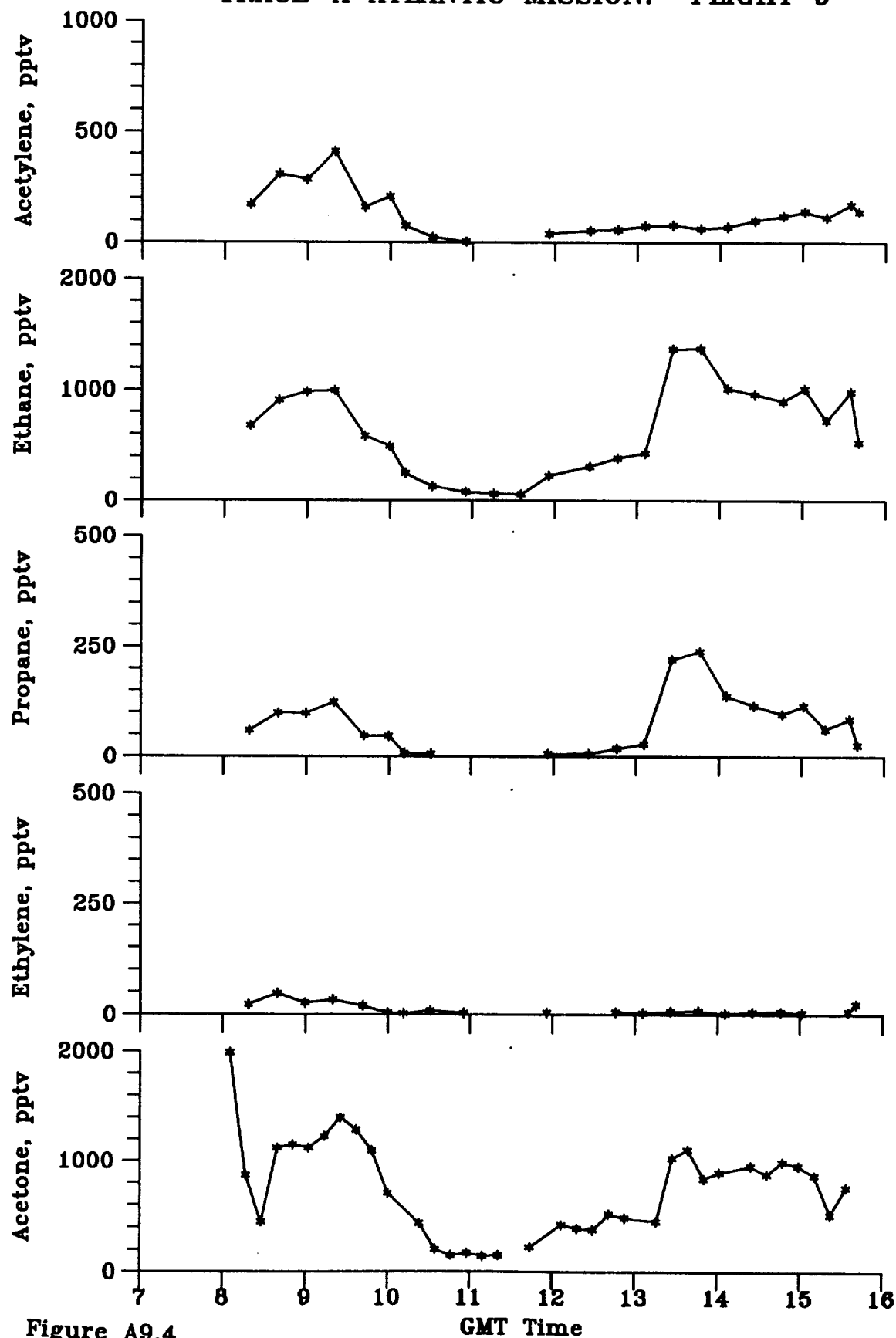


Figure A9.4

TRACE-A ATLANTIC MISSION: FLIGHT 9

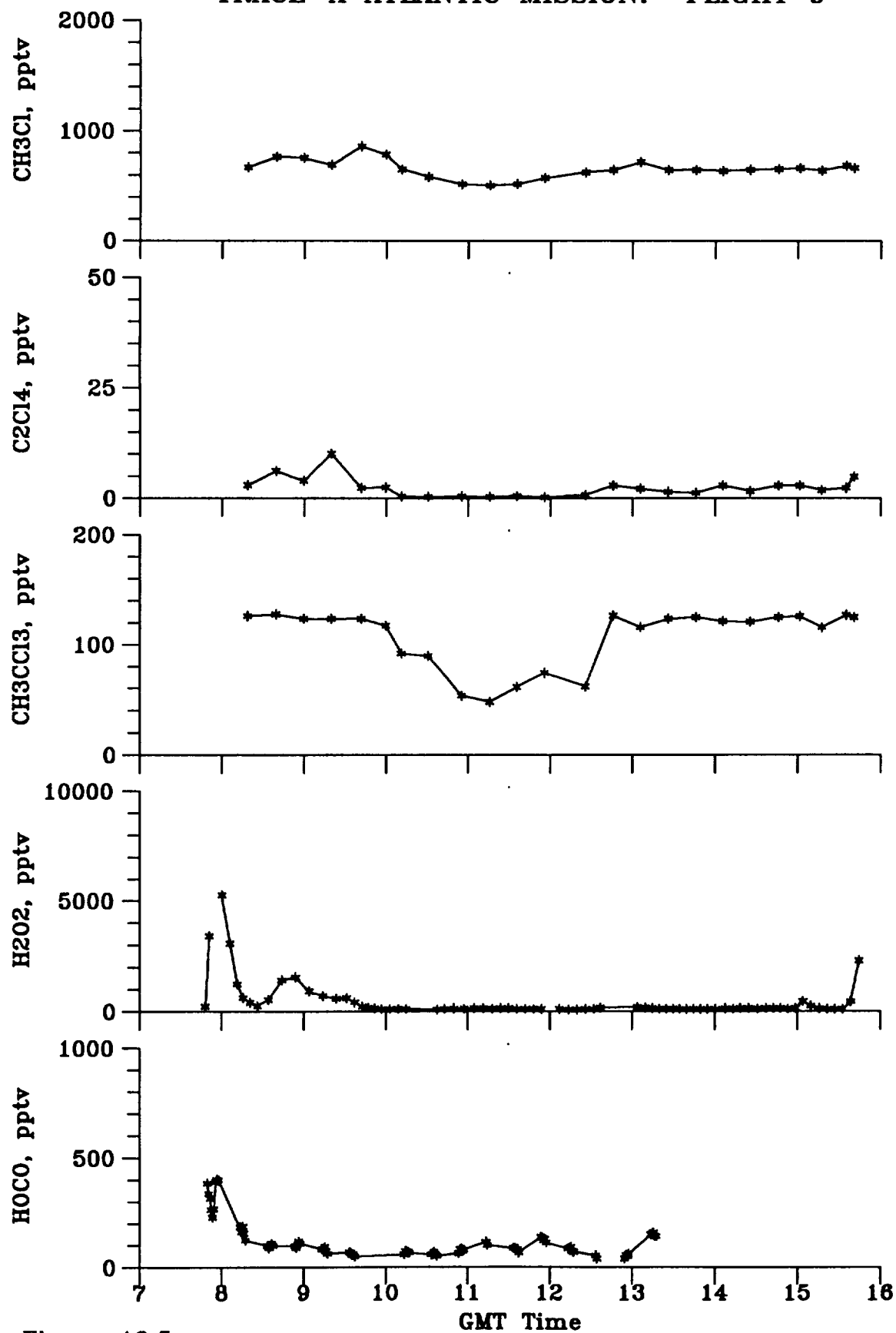


Figure A9.5

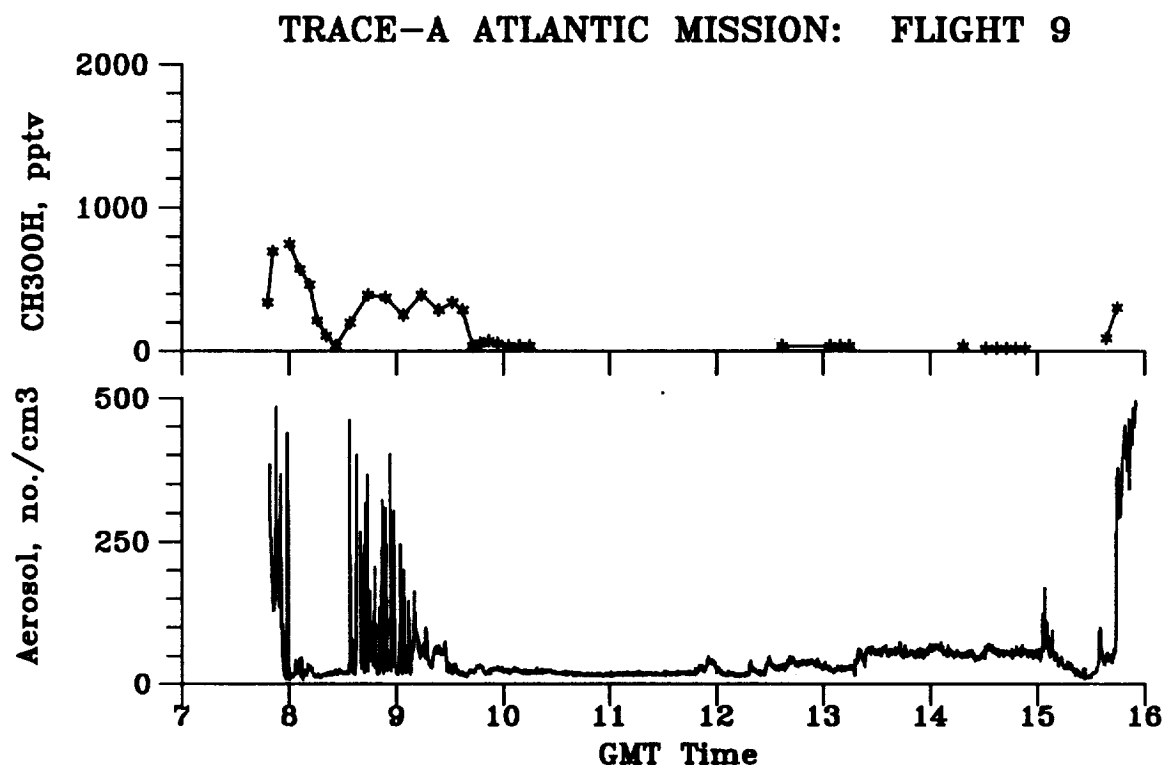


Figure A9.6

TRACE (A) ATLANTIC MISSION: FLIGHT 9 PROFILE AT 0800 GMT

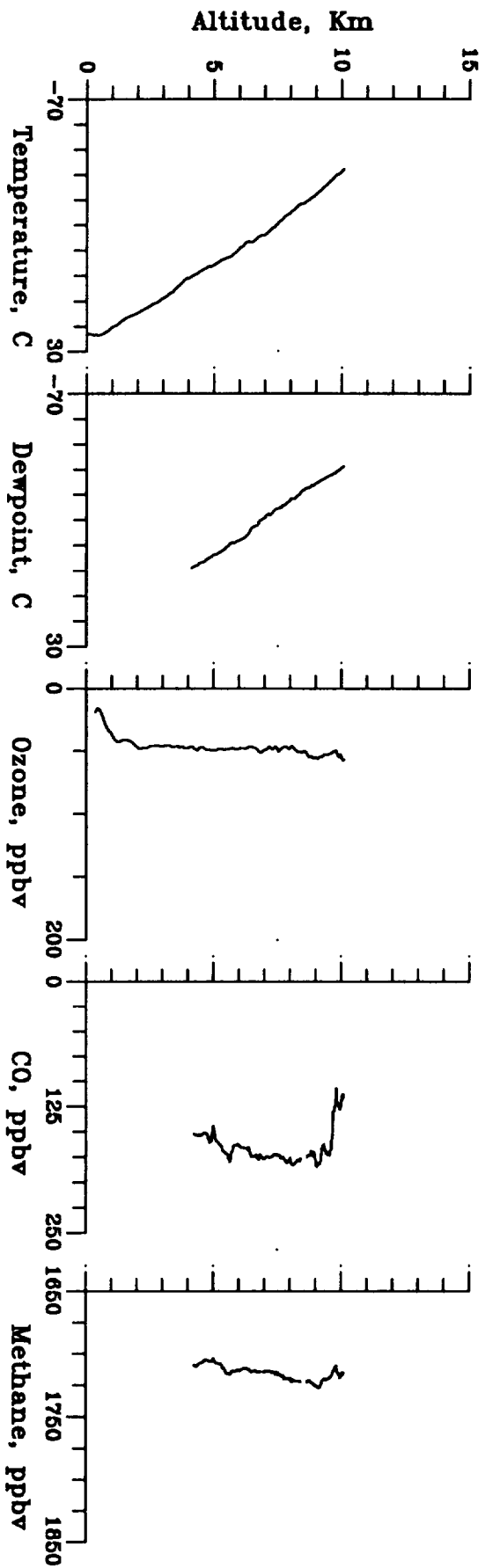
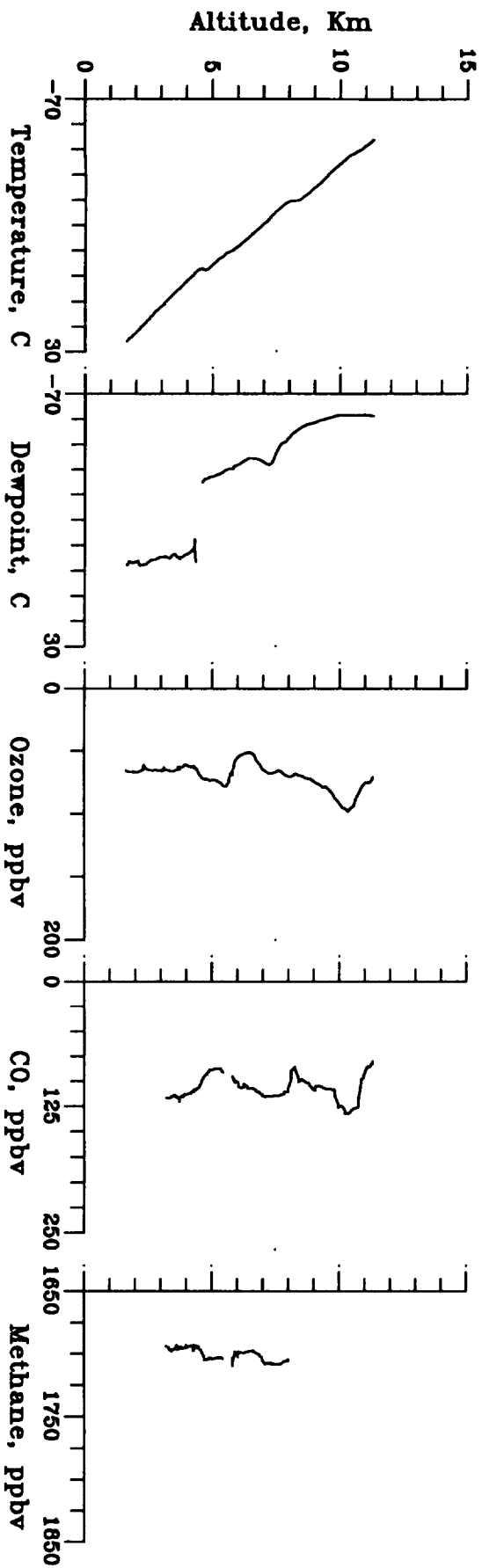


Figure A9.7

TRACE (A) ATLANTIC MISSION: FLIGHT 9 PROFILE AT 1545 GMT



TRACE-A ATLANTIC MISSION: FLIGHT 10

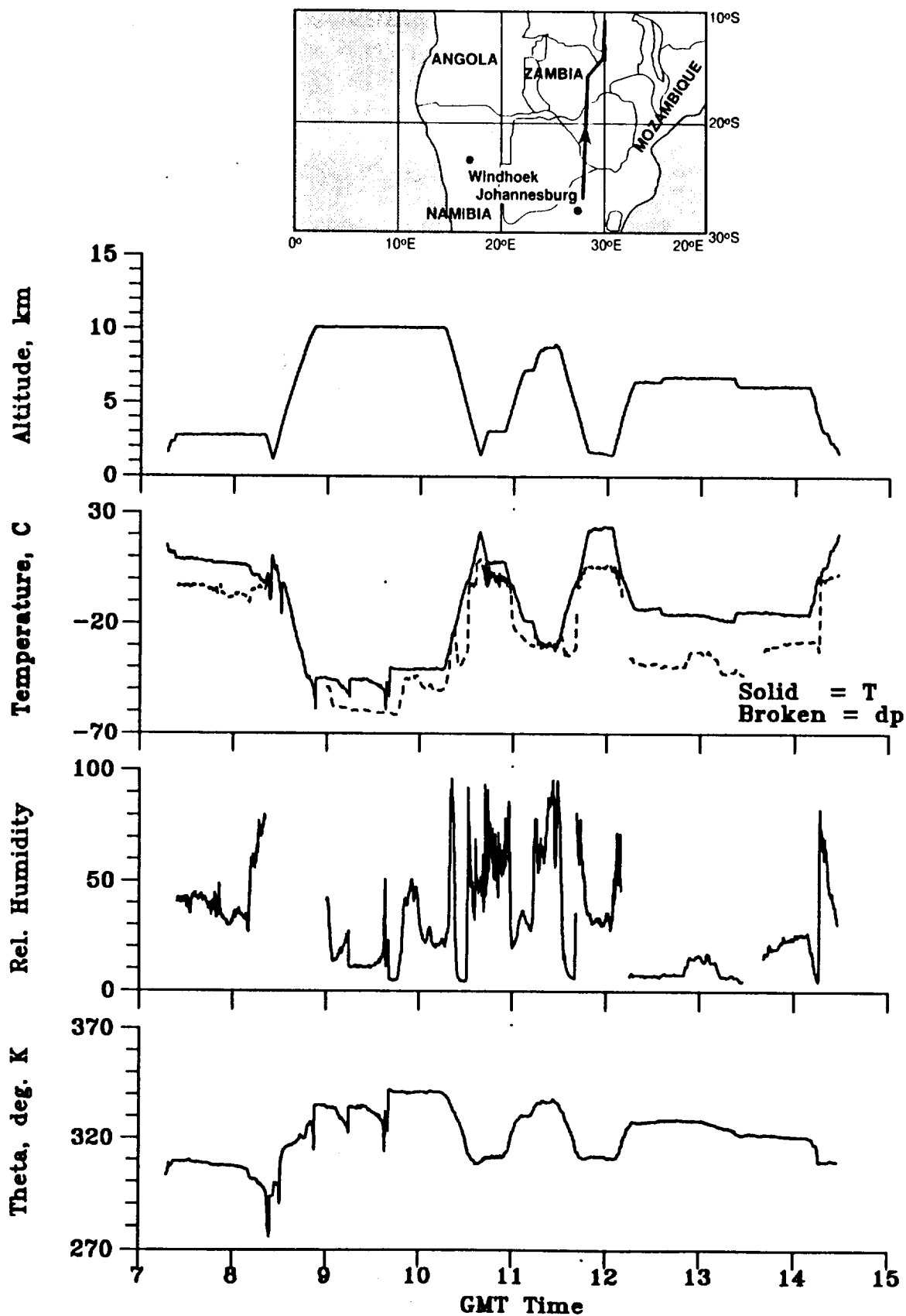


Figure A10.1

TRACE-A ATLANTIC MISSION: FLIGHT 10

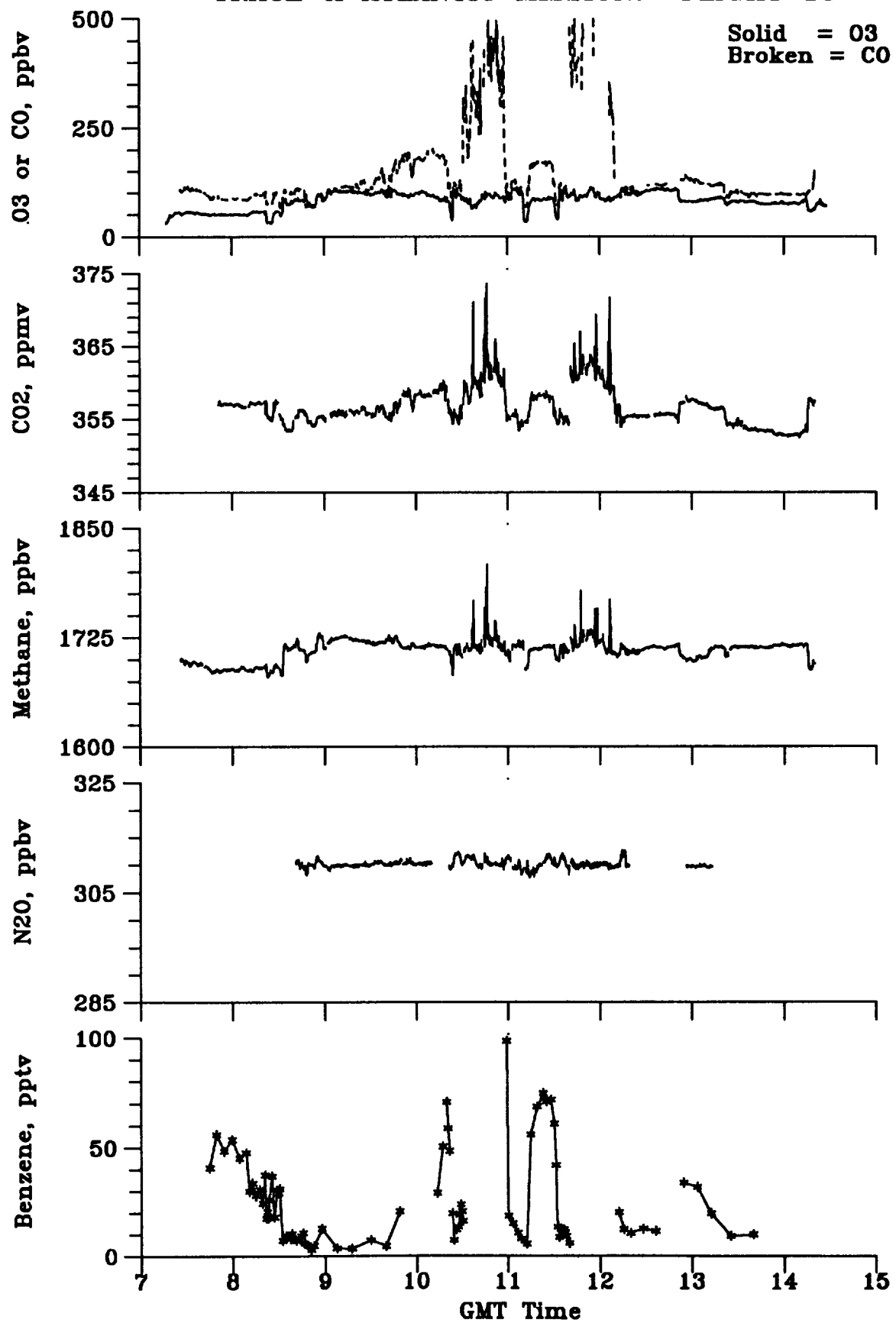


Figure A10.2

TRACE-A ATLANTIC MISSION: FLIGHT 10

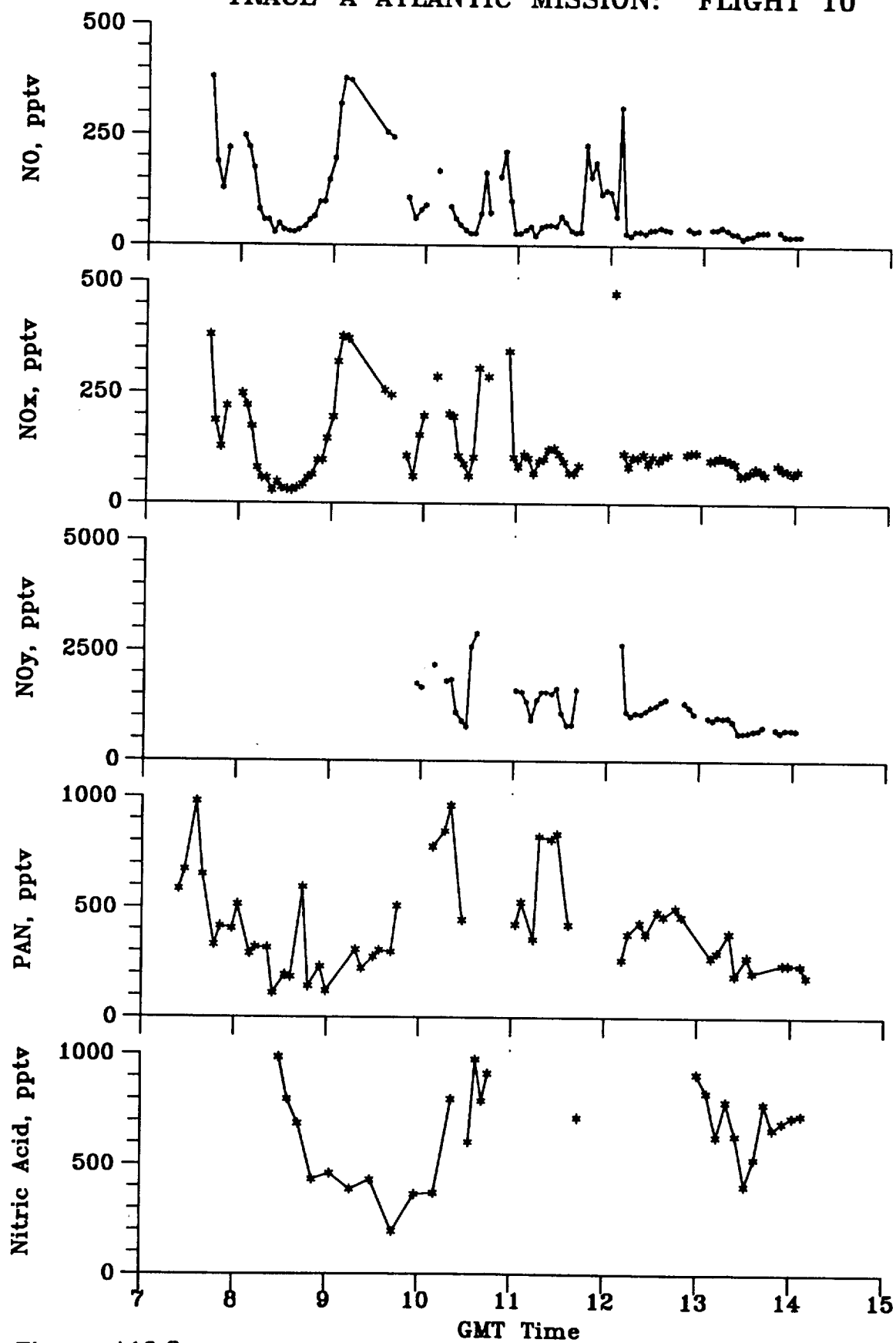


Figure A10.3

TRACE-A ATLANTIC MISSION: FLIGHT 10

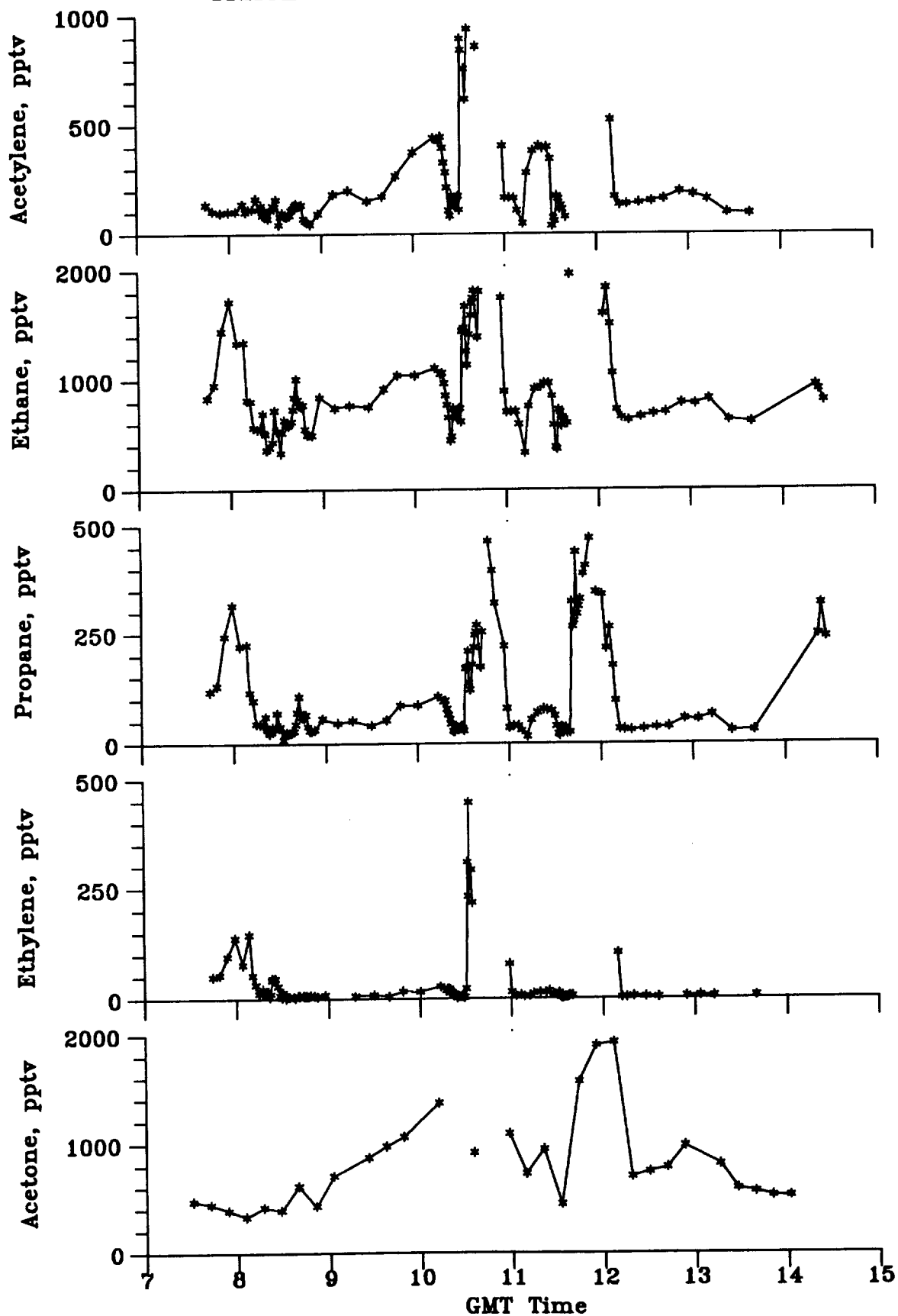


Figure A10.4

TRACE-A ATLANTIC MISSION: FLIGHT 10

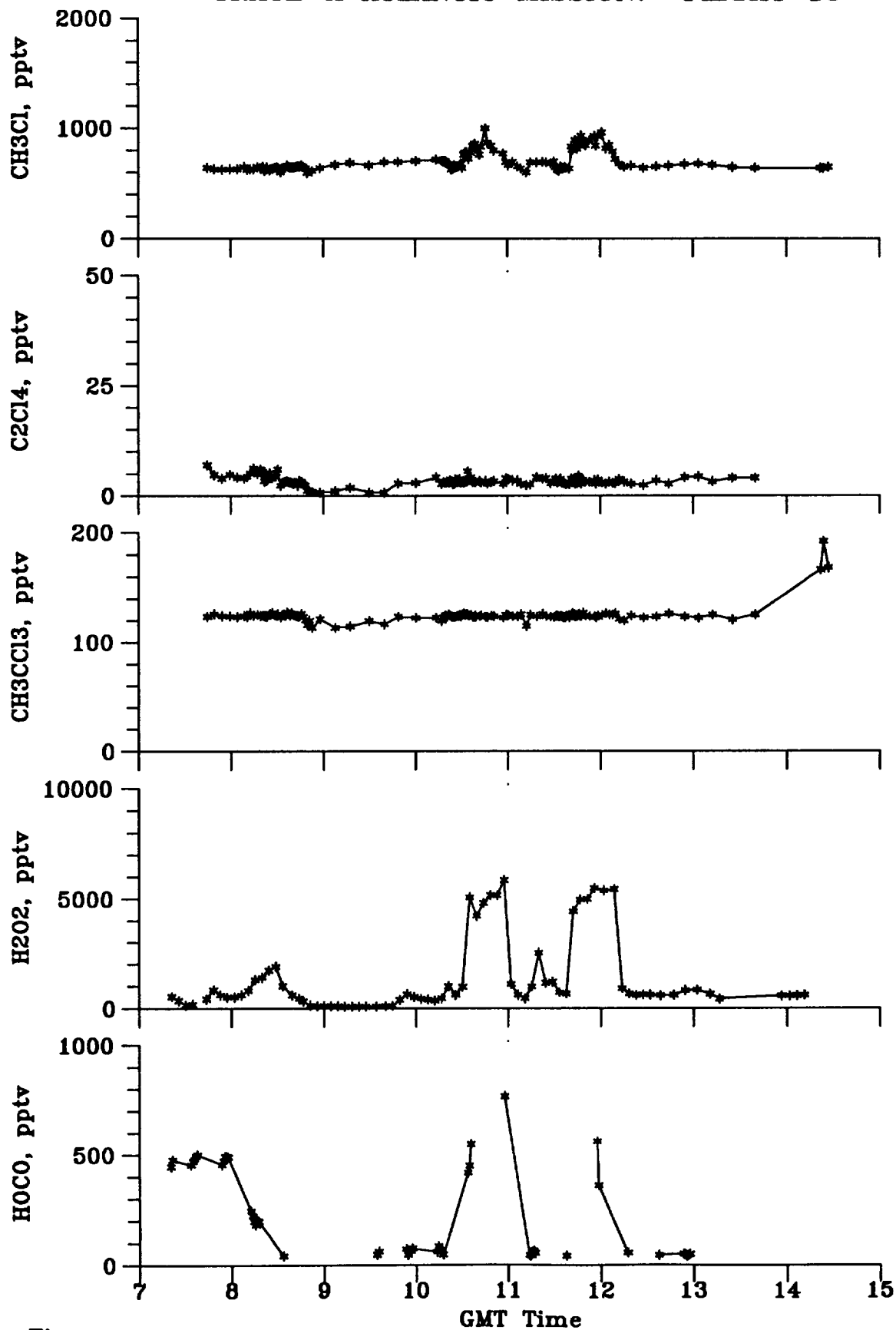


Figure A10.5

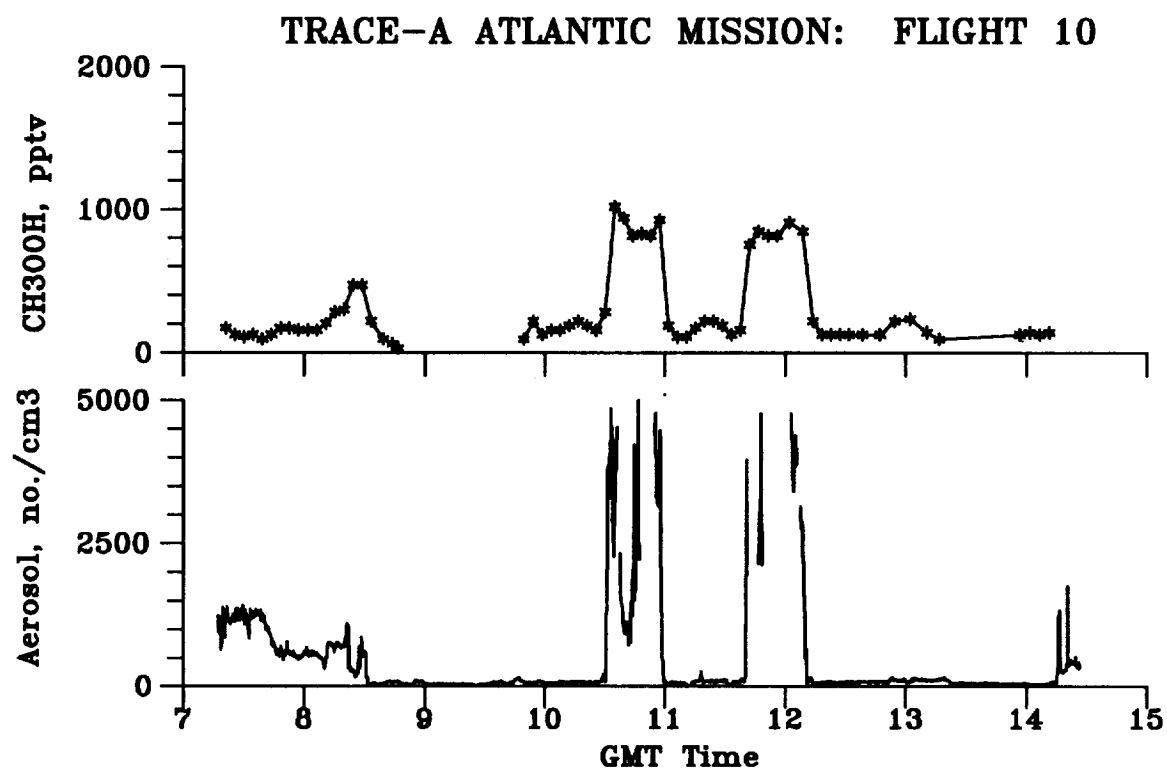
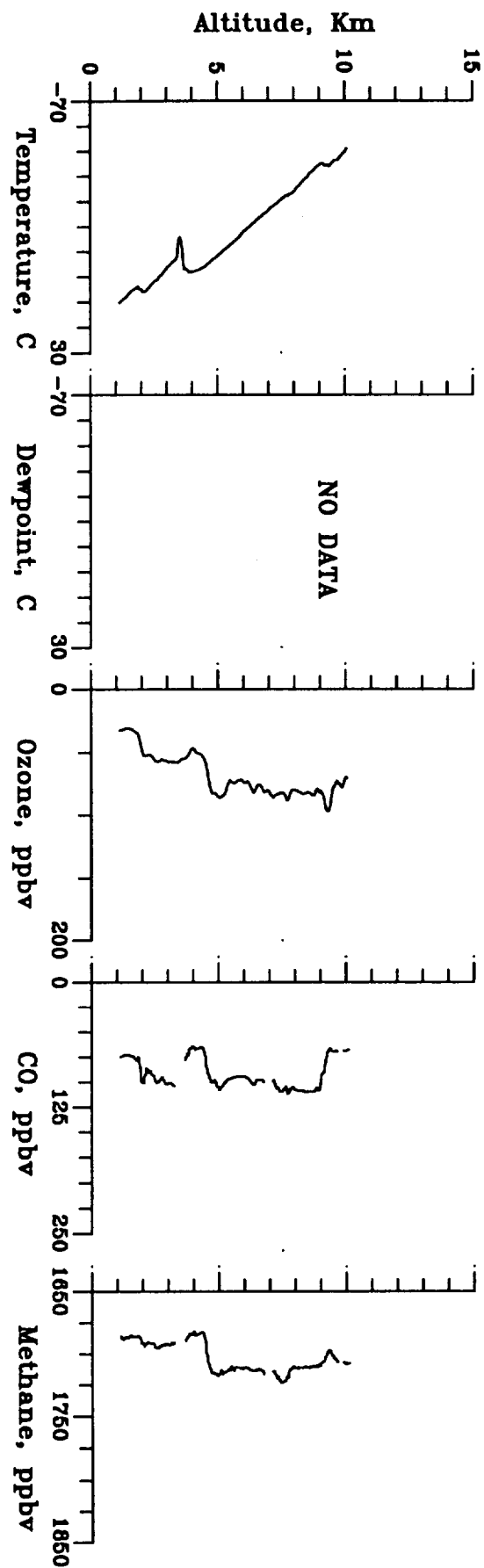
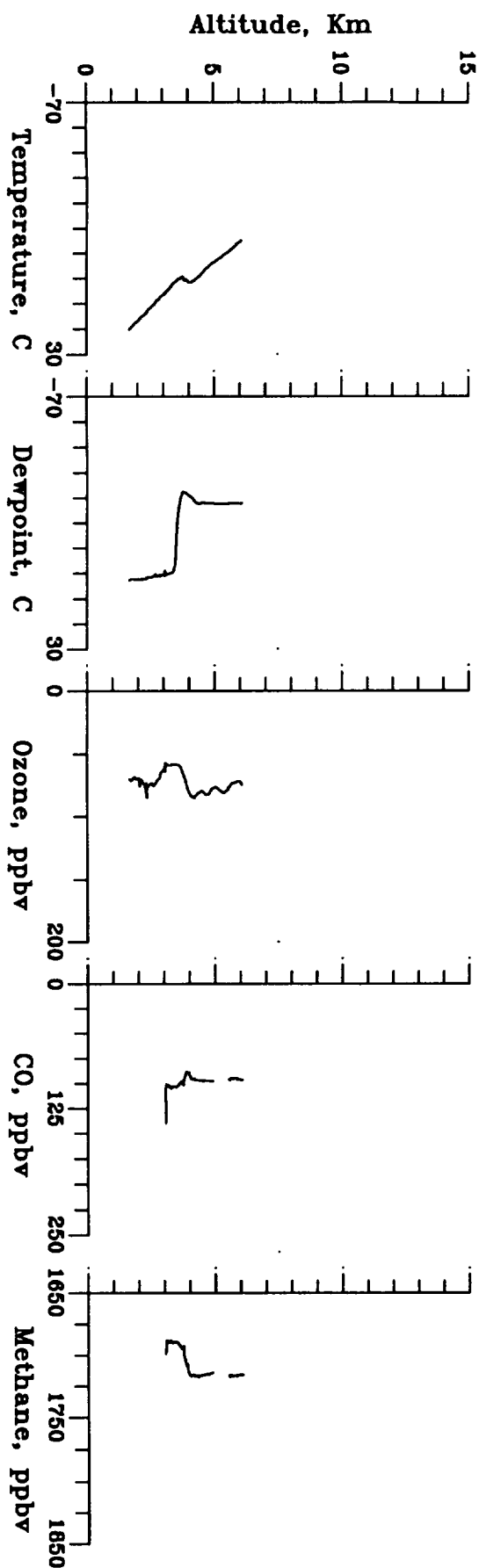


Figure A10.6

TRACE (A) ATLANTIC MISSION: FLIGHT 10 PROFILE AT 0830 GMT



TRACE (A) ATLANTIC MISSION: FLIGHT 10 PROFILE AT 1415 GMT



TRACE-A ATLANTIC MISSION: FLIGHT 11

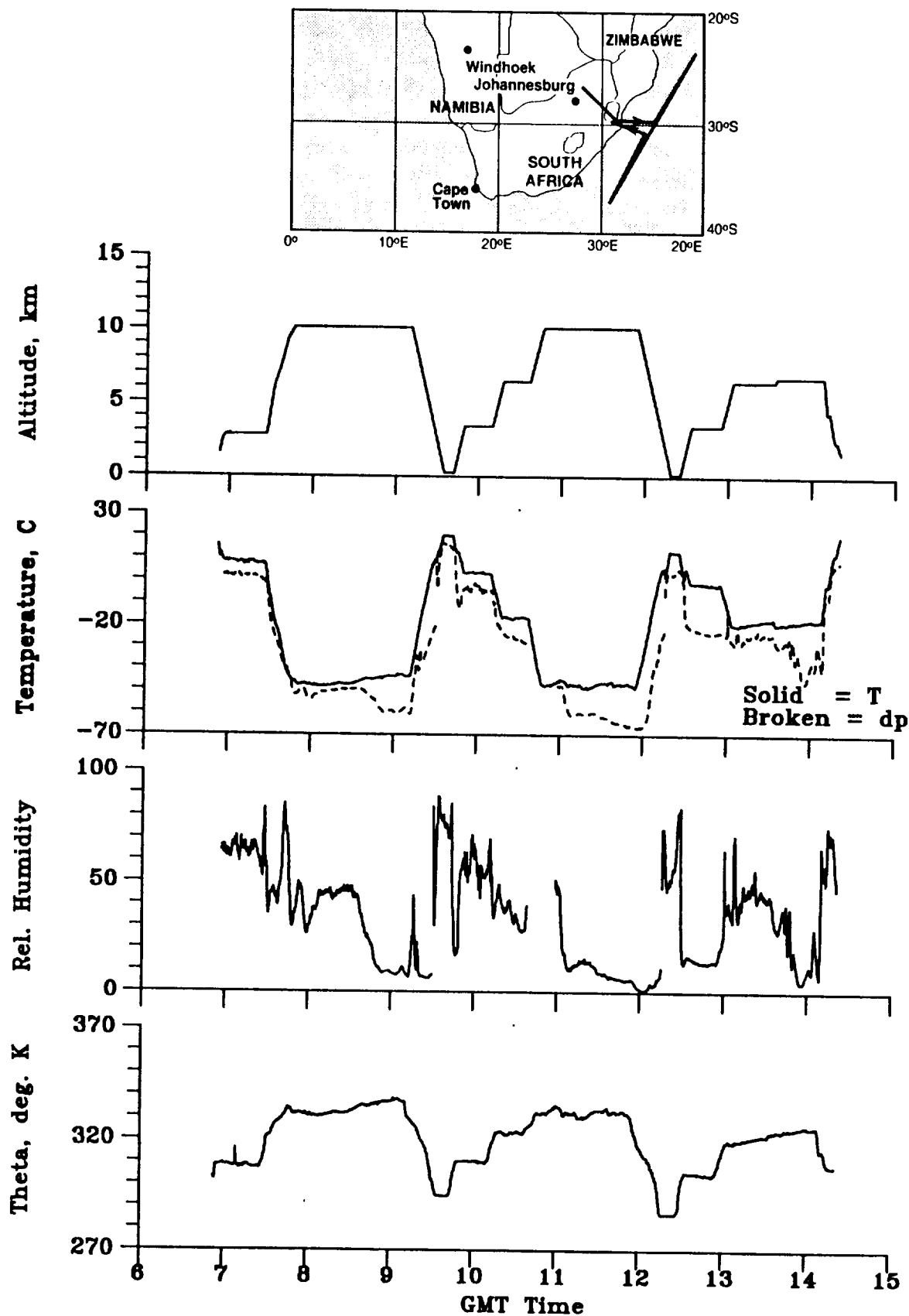


Figure A11.1

TRACE-A ATLANTIC MISSION: FLIGHT 11

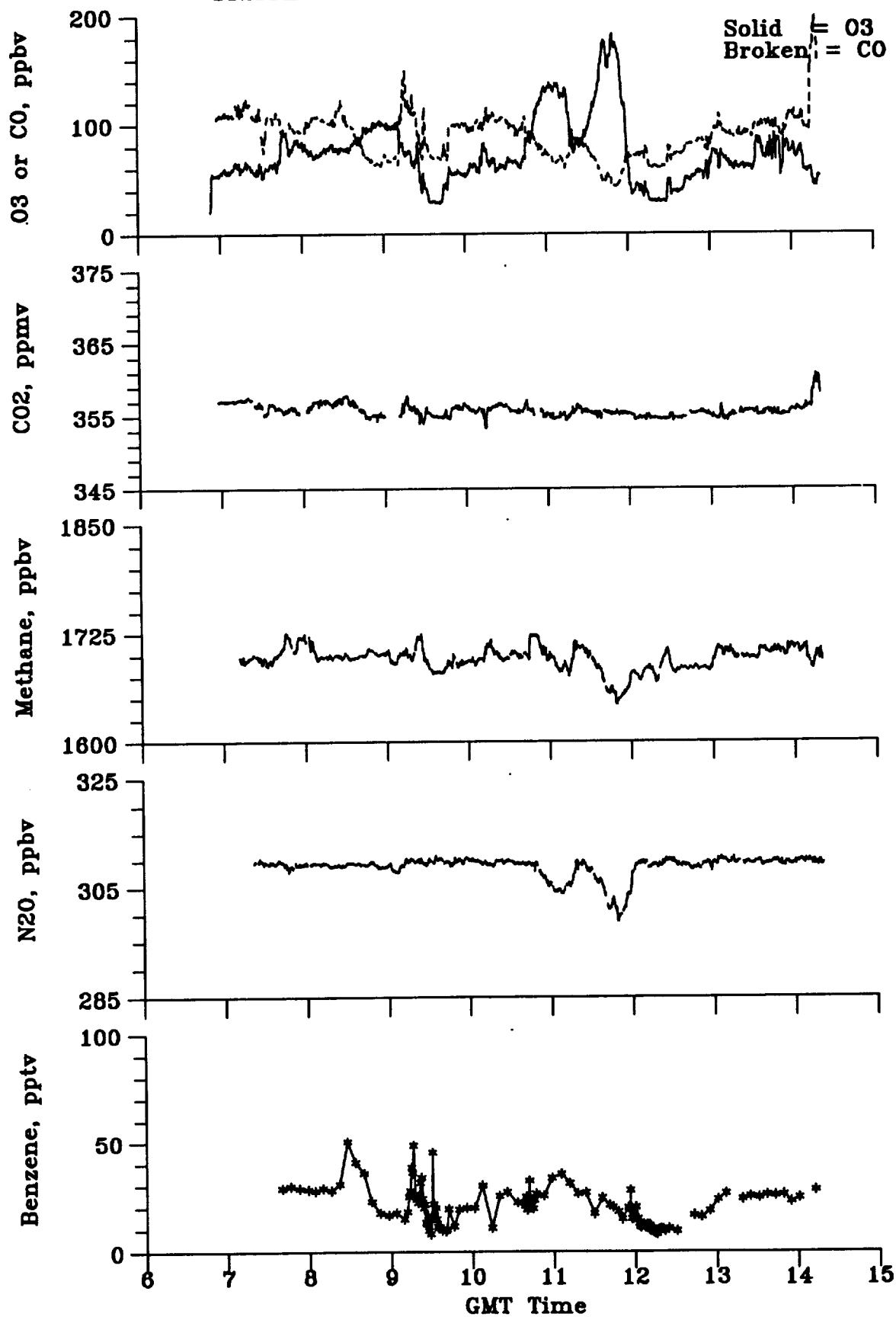


Figure A11.2

TRACE-A ATLANTIC MISSION: FLIGHT 11

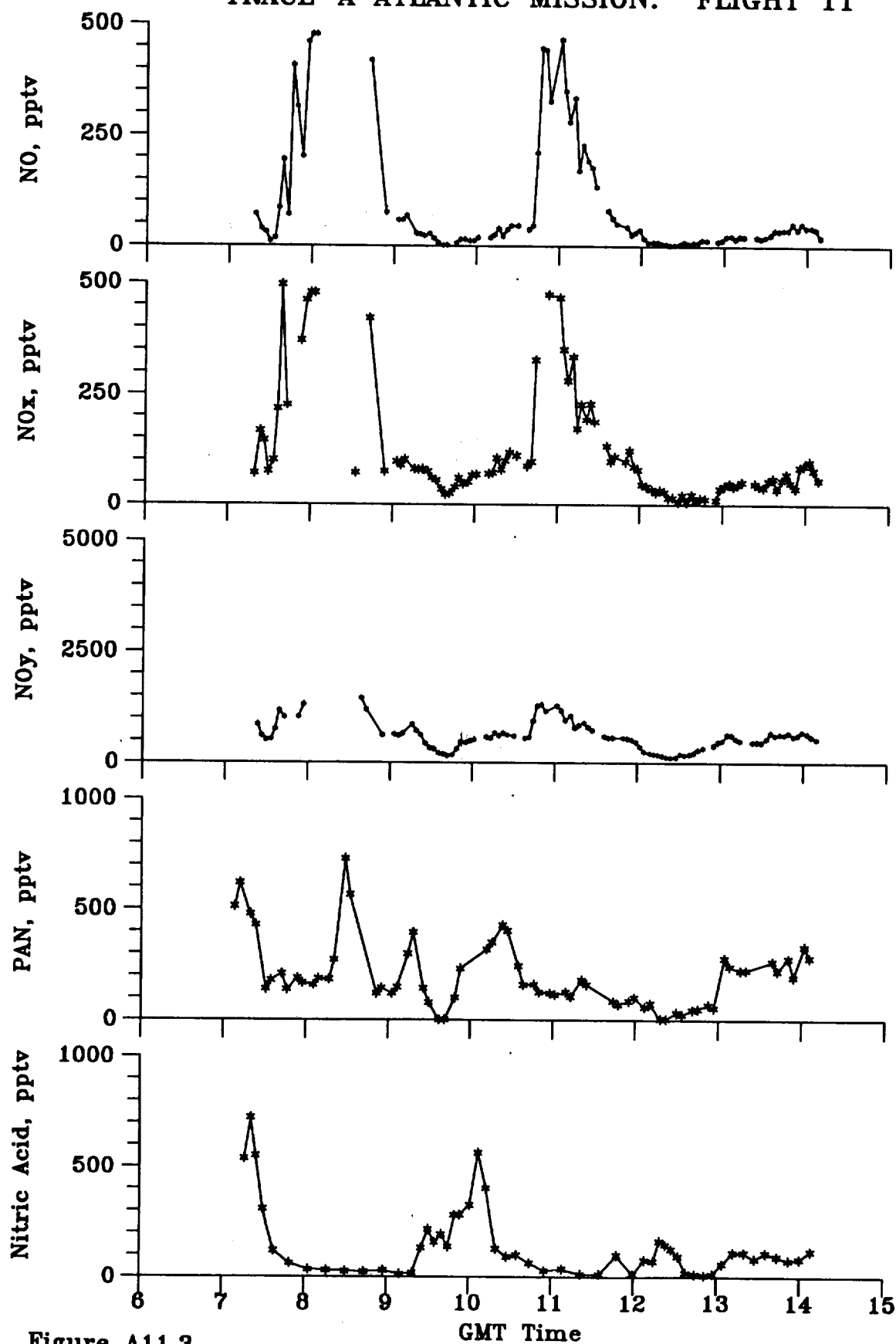


Figure A11.3

TRACE-A ATLANTIC MISSION: FLIGHT 11

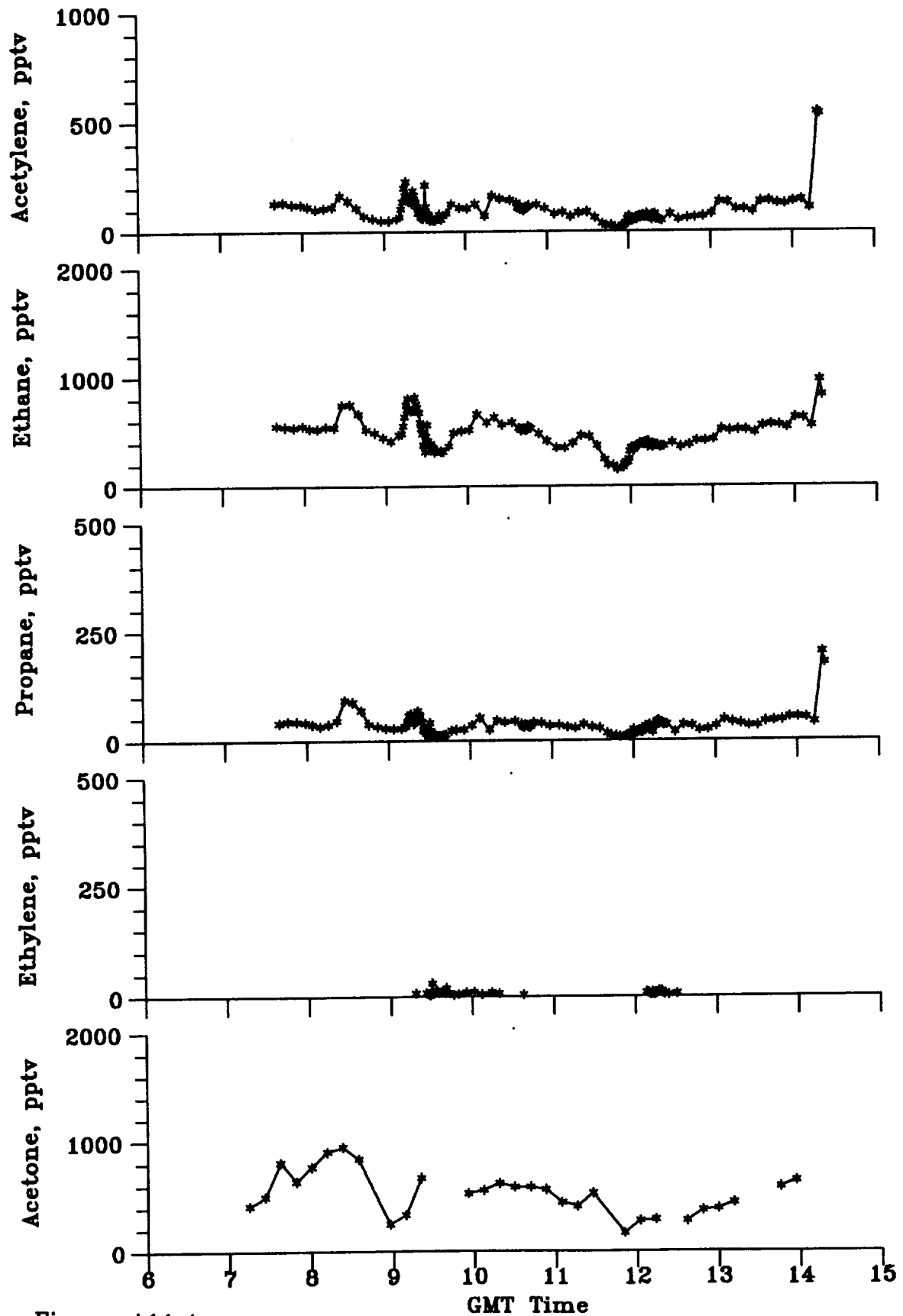


Figure A11.4

TRACE-A ATLANTIC MISSION: FLIGHT 11

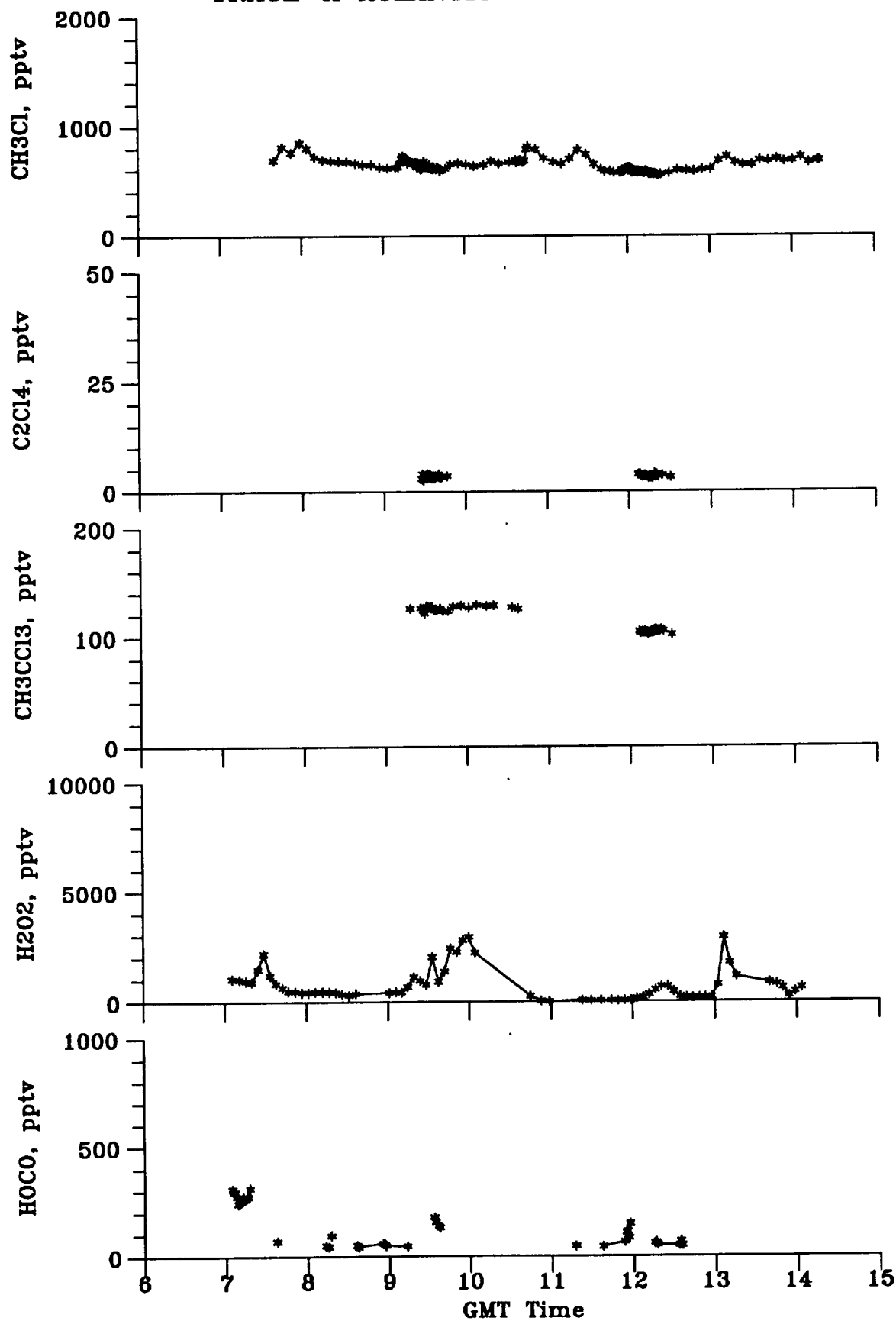


Figure A11.5

TRACE-A ATLANTIC MISSION: FLIGHT 11

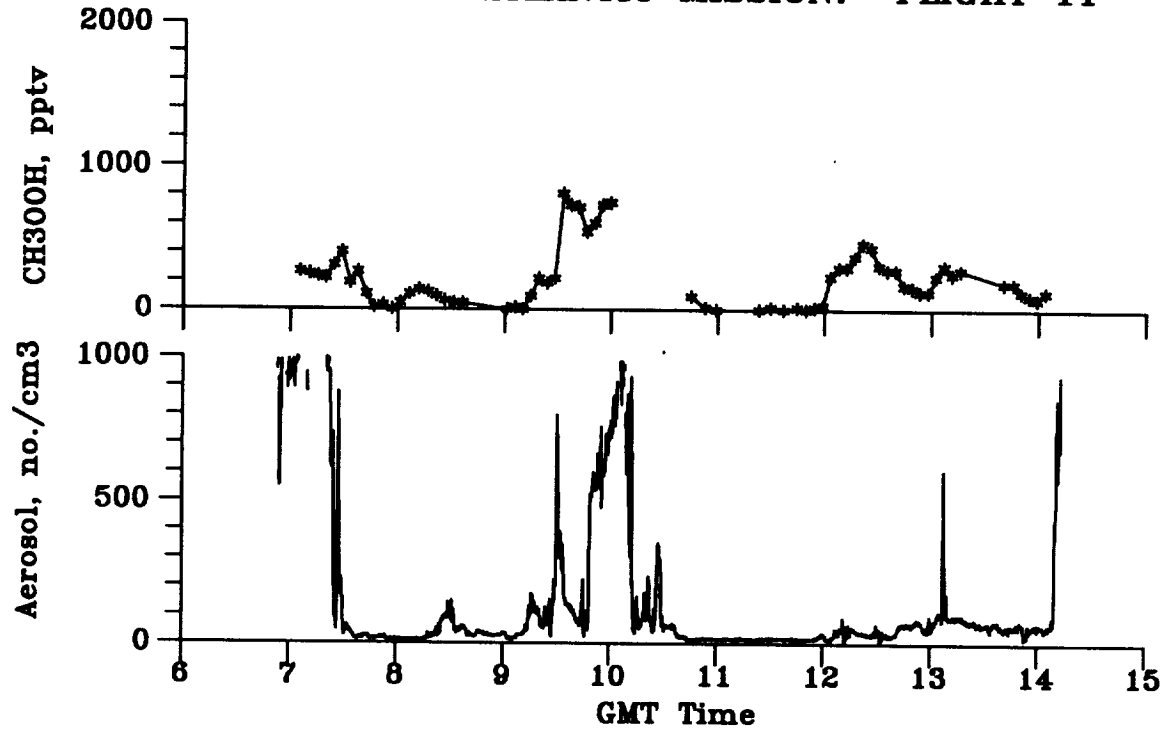
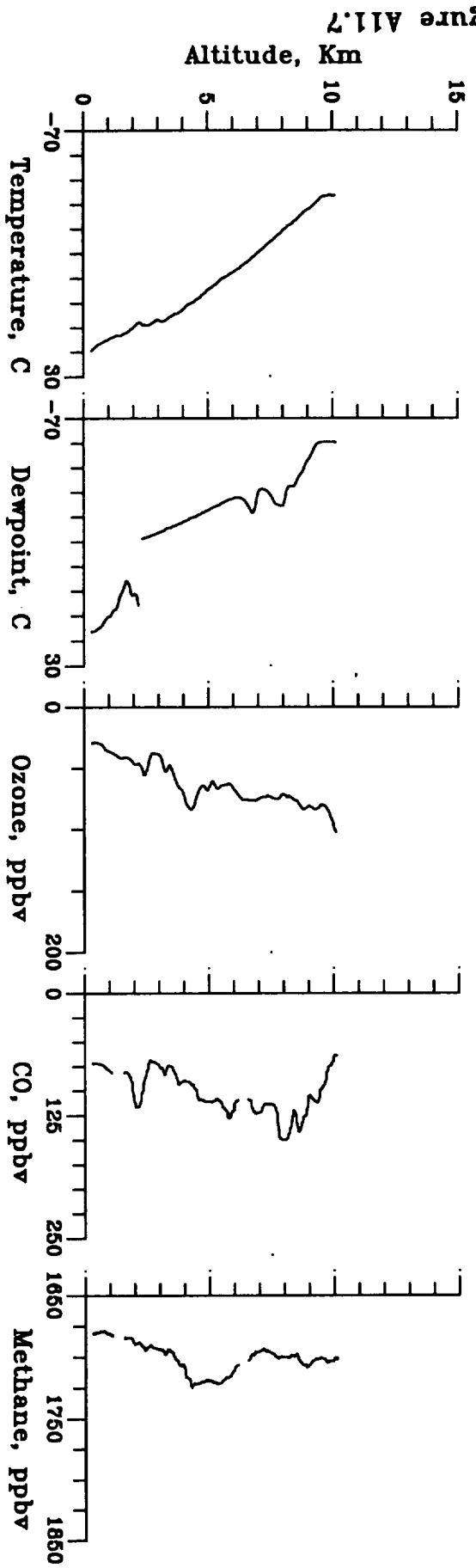
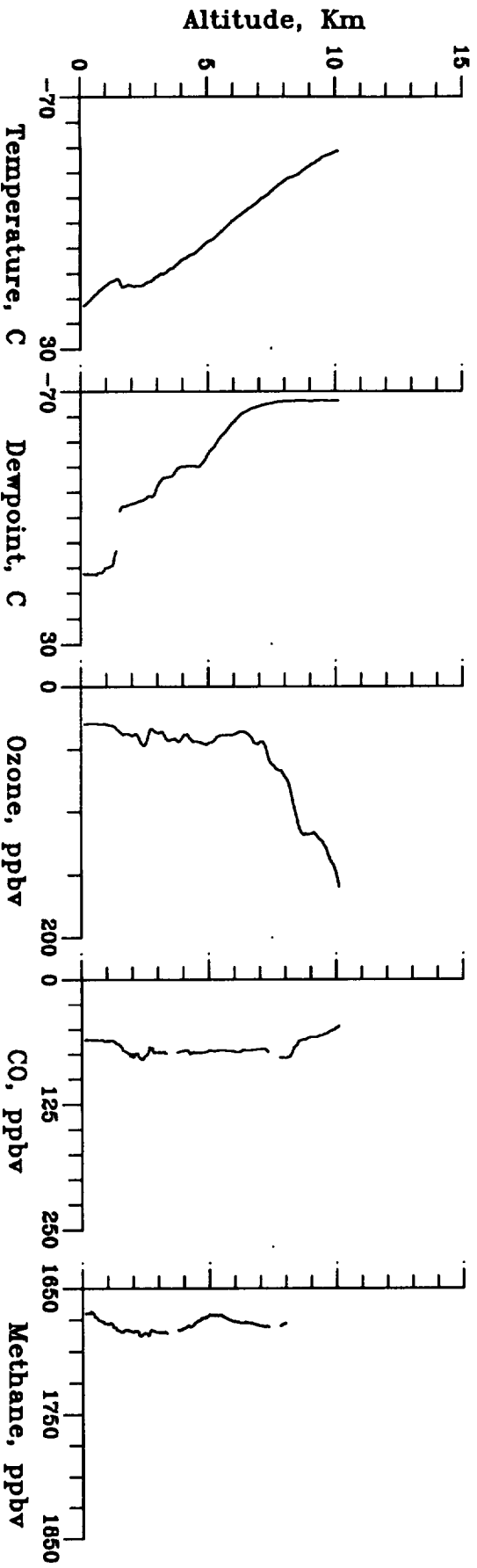


Figure A11.6

TRACE (A) ATLANTIC MISSION: FLIGHT 11 PROFILE AT 0930 GMT



TRACE (A) ATLANTIC MISSION: FLIGHT 11 PROFILE AT 1200 GMT



TRACE-A ATLANTIC MISSION: FLIGHT 12

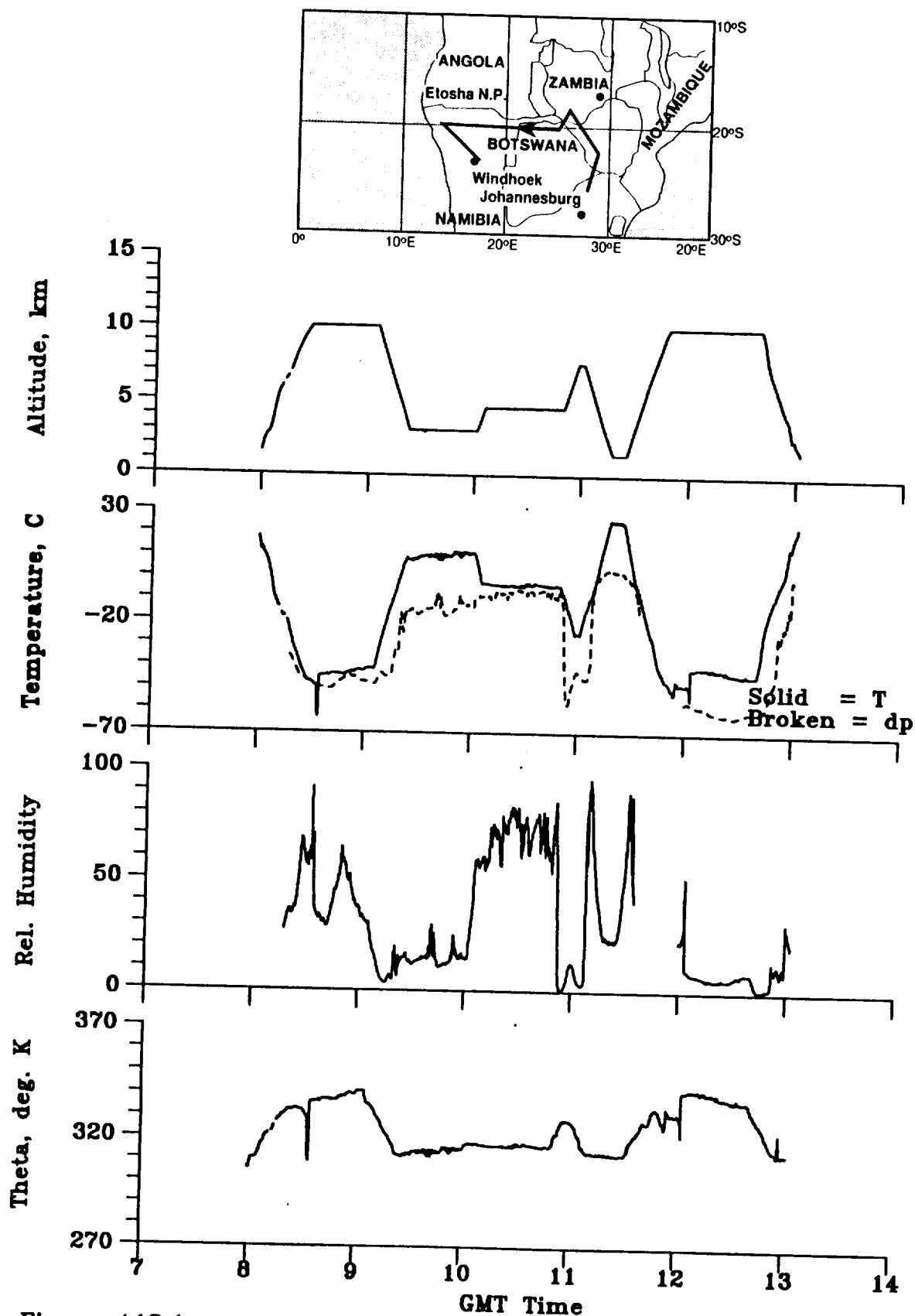


Figure A12.1

TRACE-A ATLANTIC MISSION: FLIGHT 12

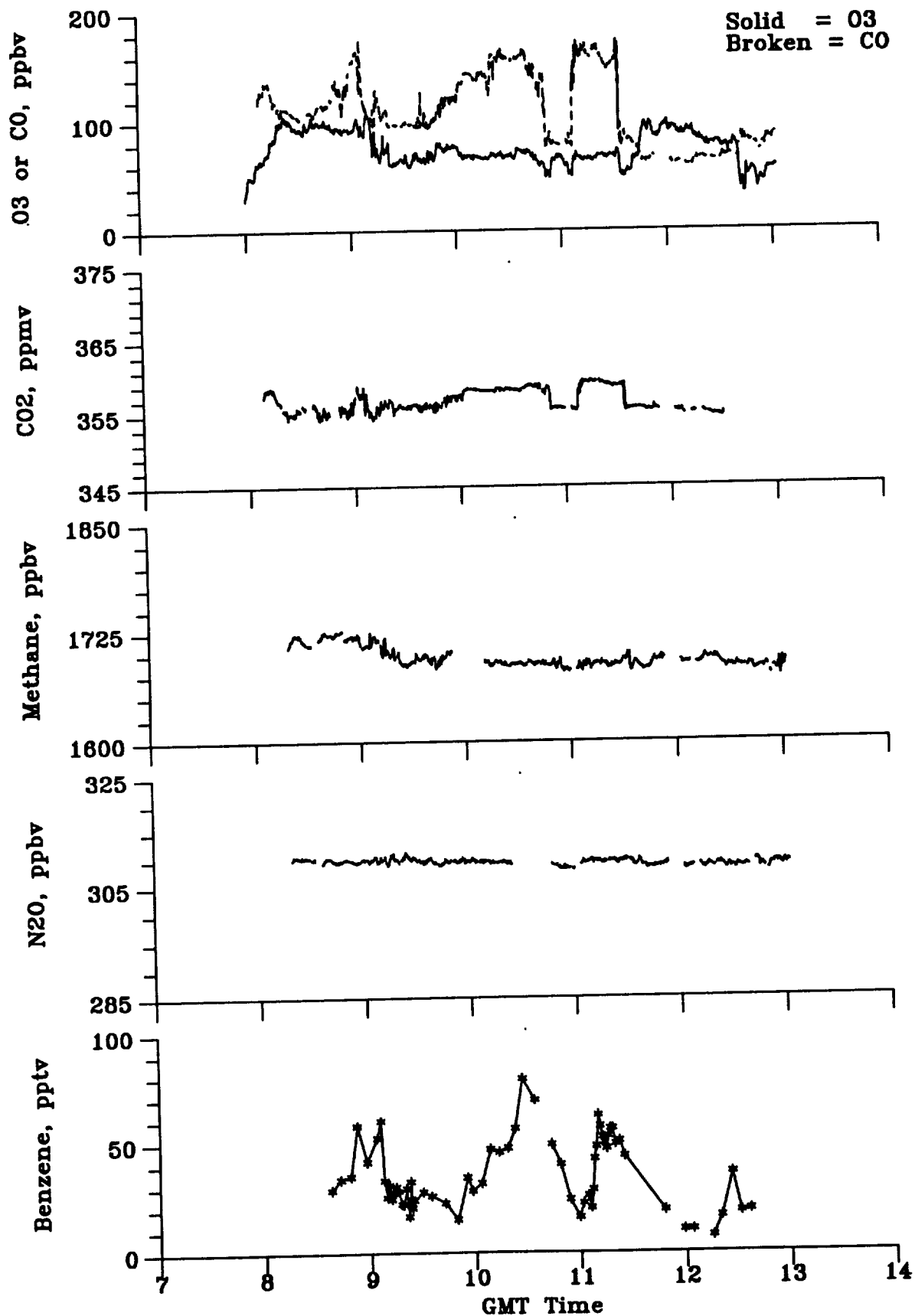


Figure A12.2

TRACE-A ATLANTIC MISSION: FLIGHT 12

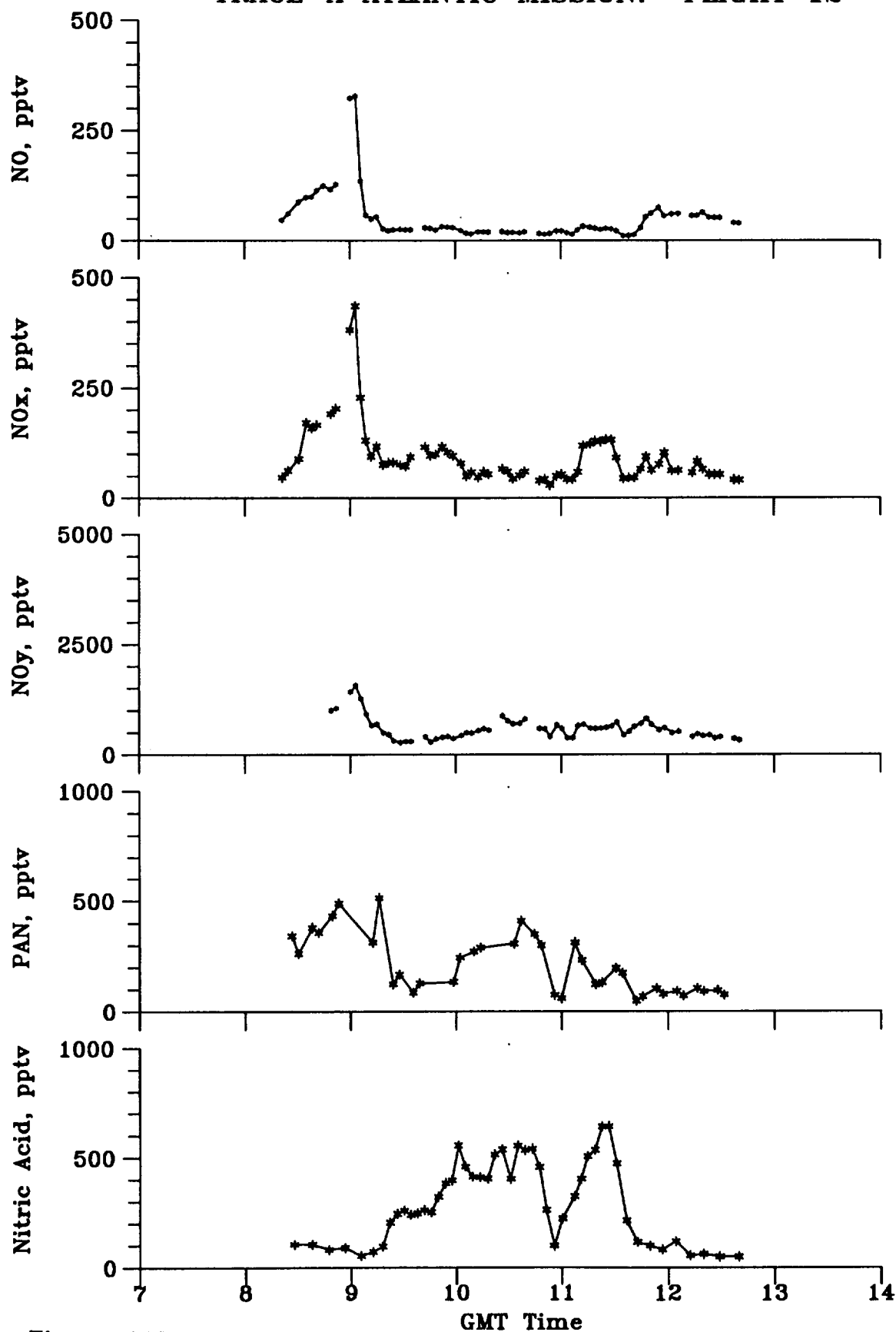


Figure A12.3

TRACE-A ATLANTIC MISSION: FLIGHT 12

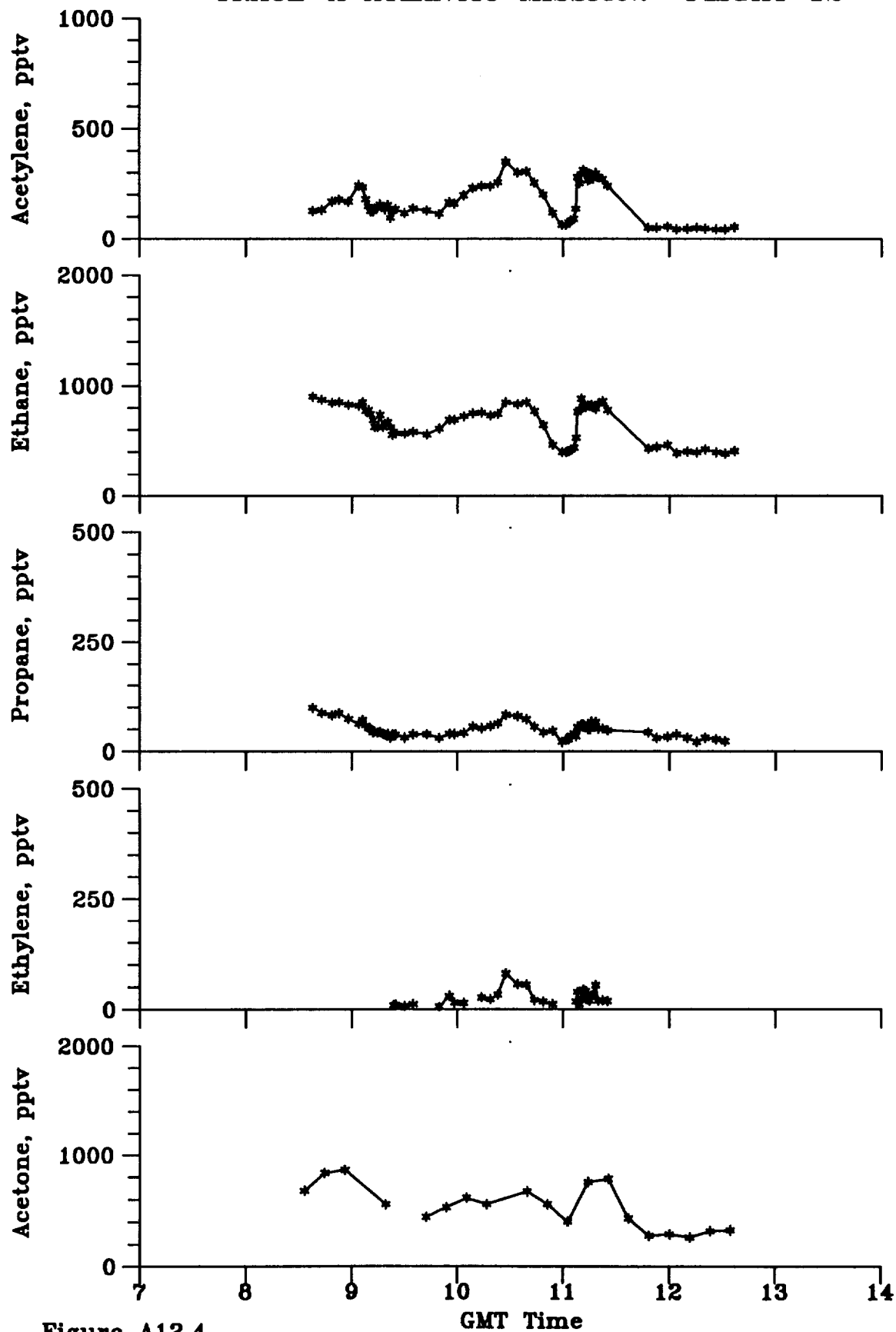


Figure A12.4

TRACE-A ATLANTIC MISSION: FLIGHT 12

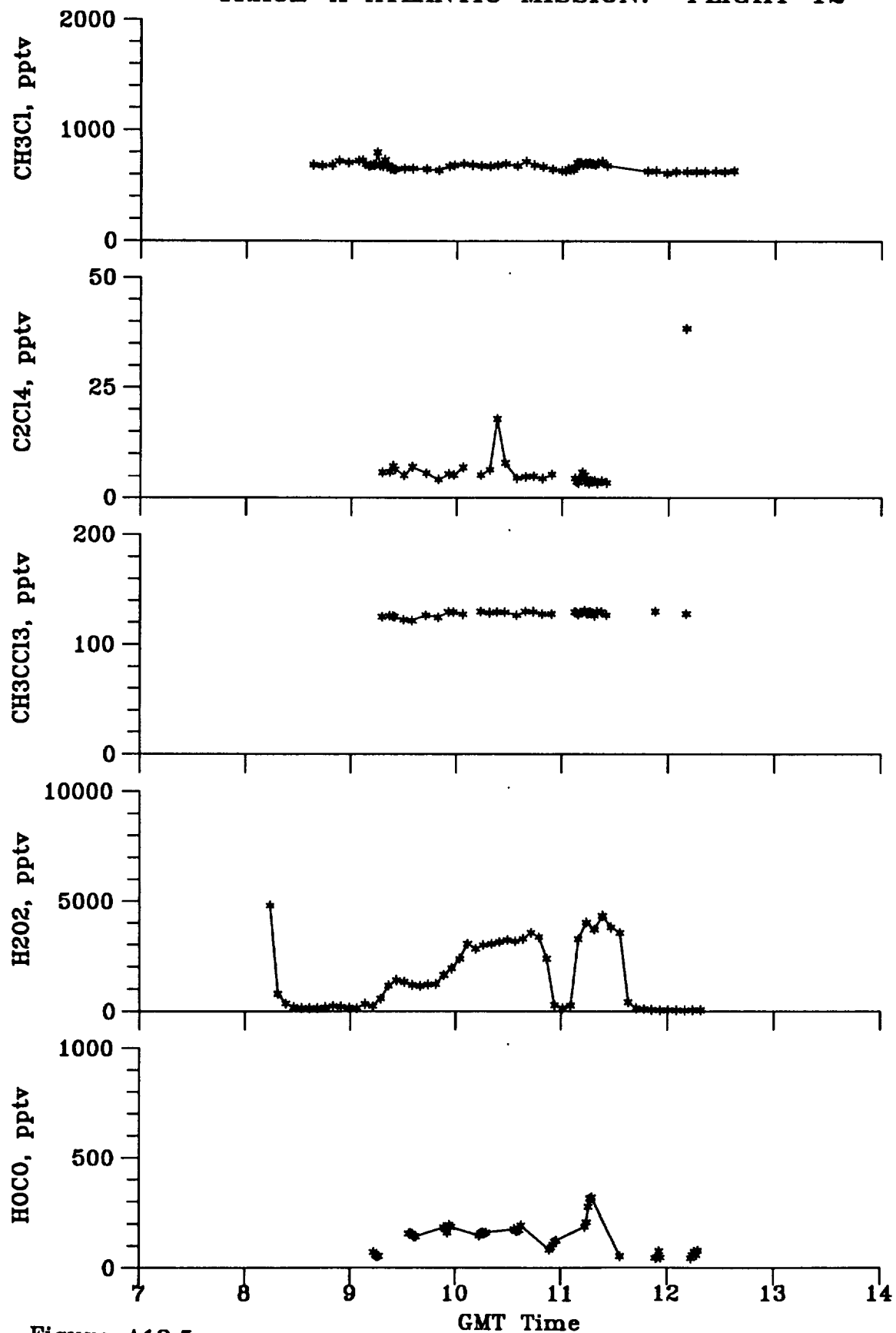


Figure A12.5

TRACE-A ATLANTIC MISSION: FLIGHT 12

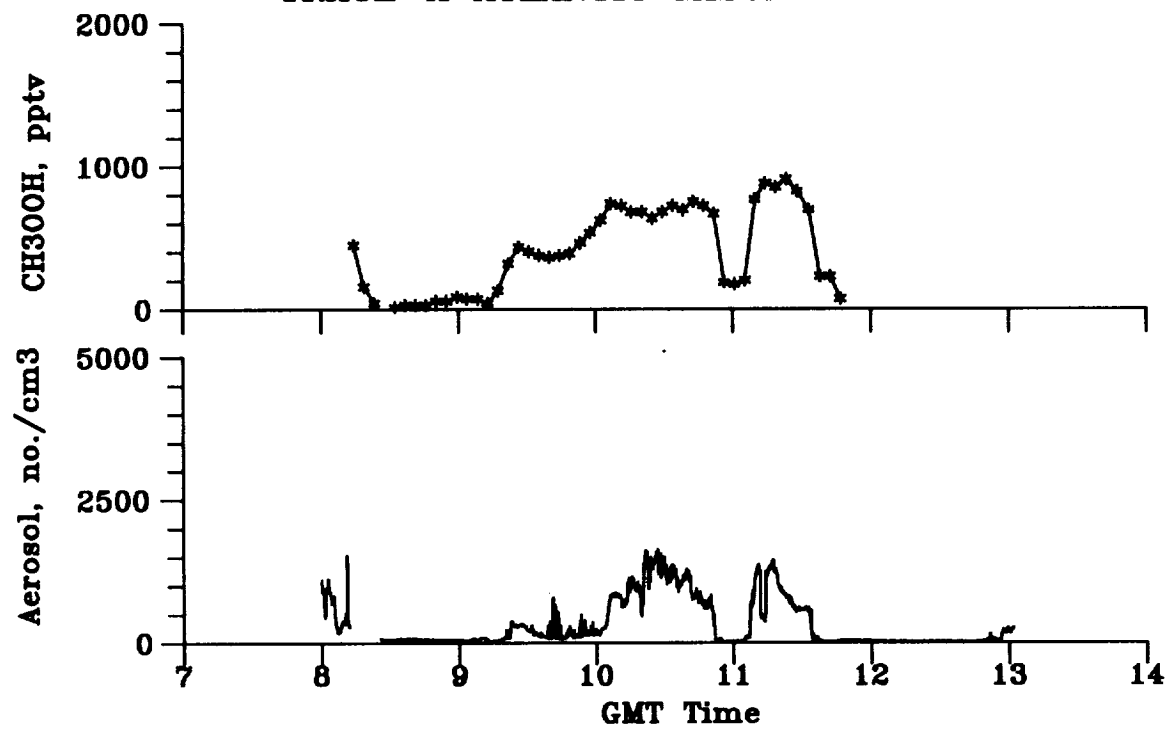
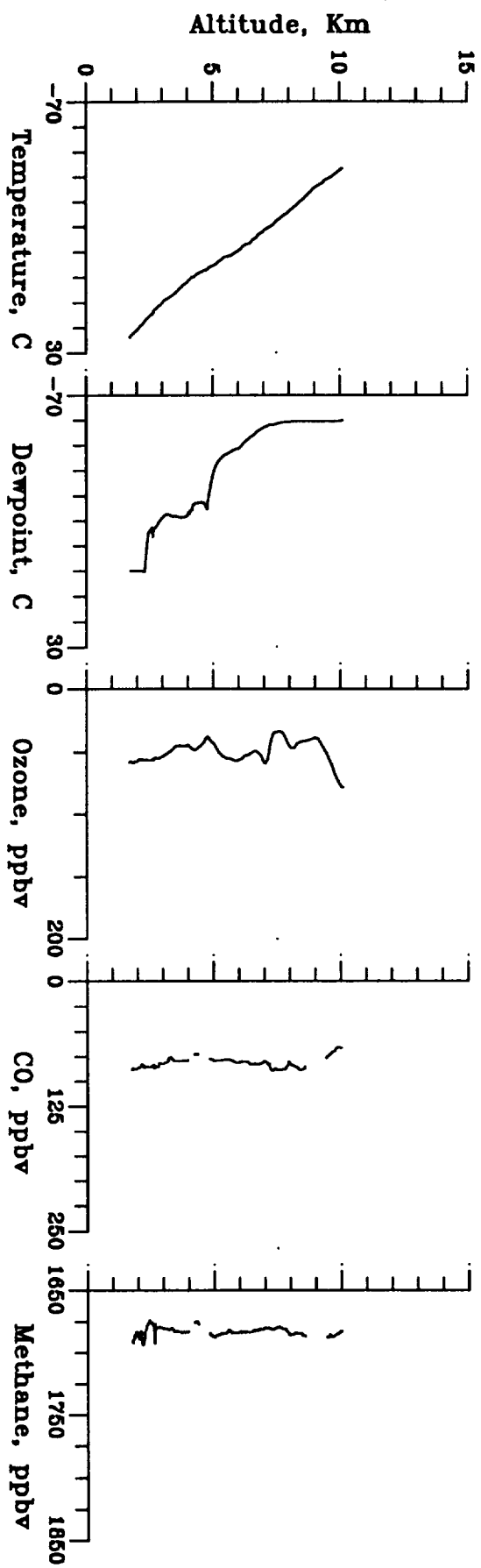
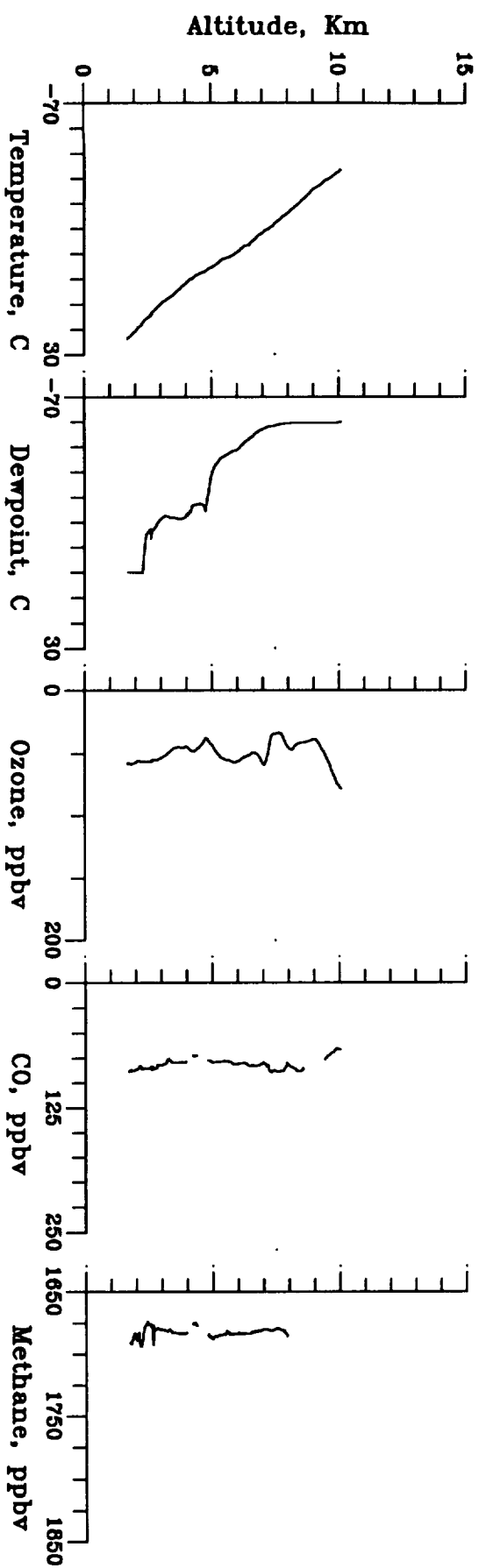


Figure A12.6

TRACE (A) ATLANTIC MISSION: FLIGHT 12 PROFILE AT 0815 GMT



TRACE (A) ATLANTIC MISSION: FLIGHT 12 PROFILE AT 1245 GMT



TRACE-A ATLANTIC MISSION: FLIGHT 13

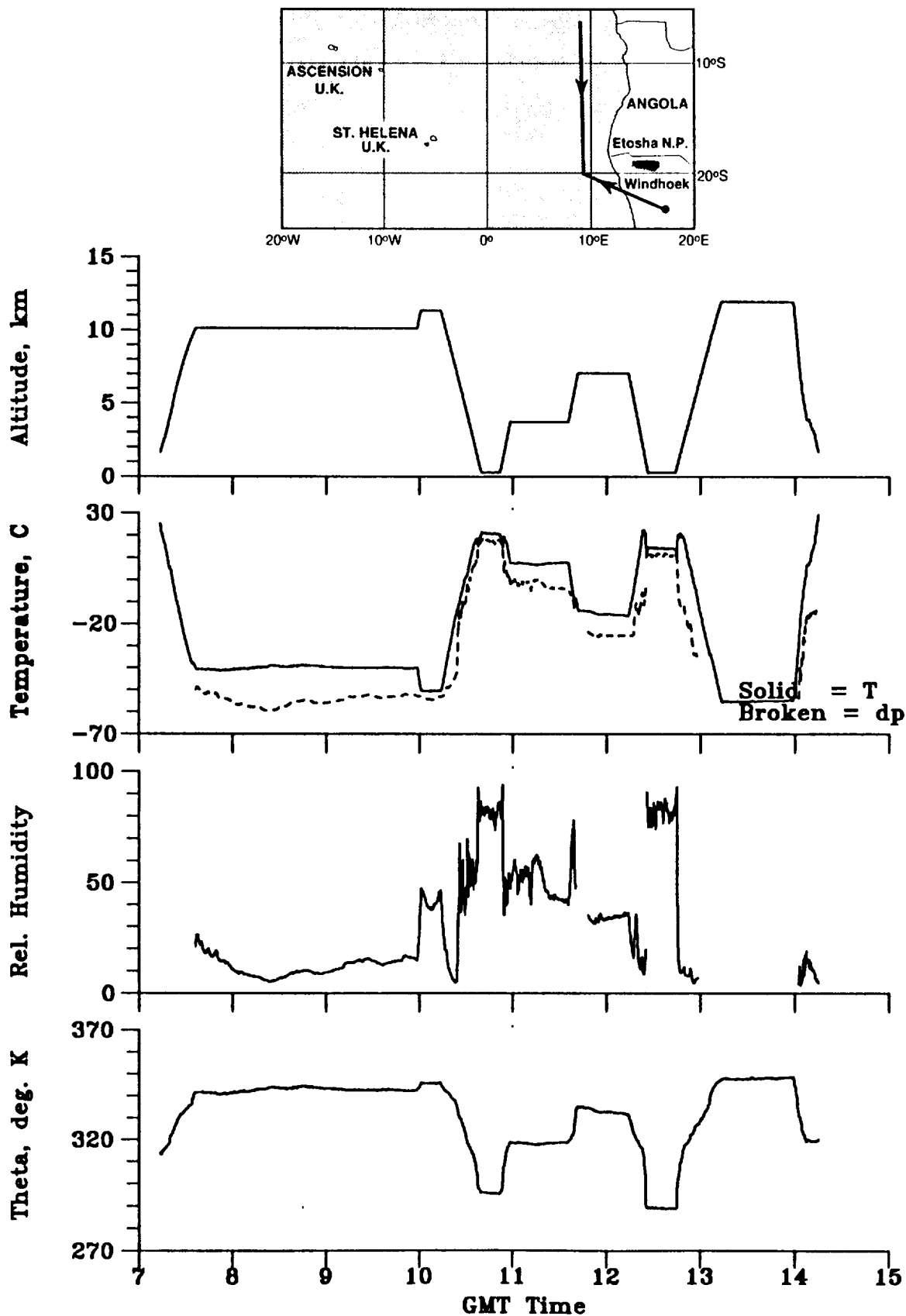


Figure A13.1

TRACE-A ATLANTIC MISSION: FLIGHT 13

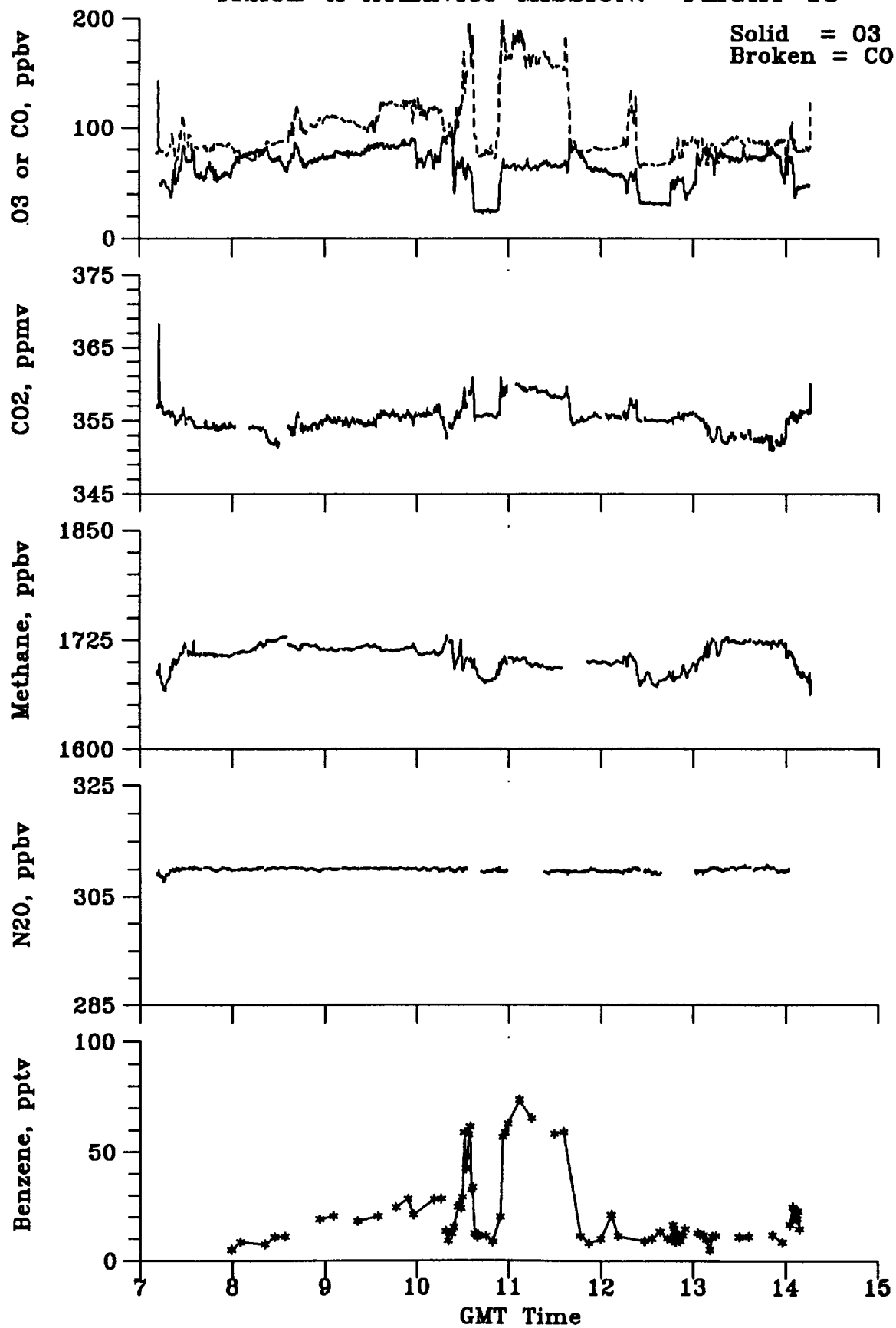


Figure A13.2

TRACE-A ATLANTIC MISSION: FLIGHT 13

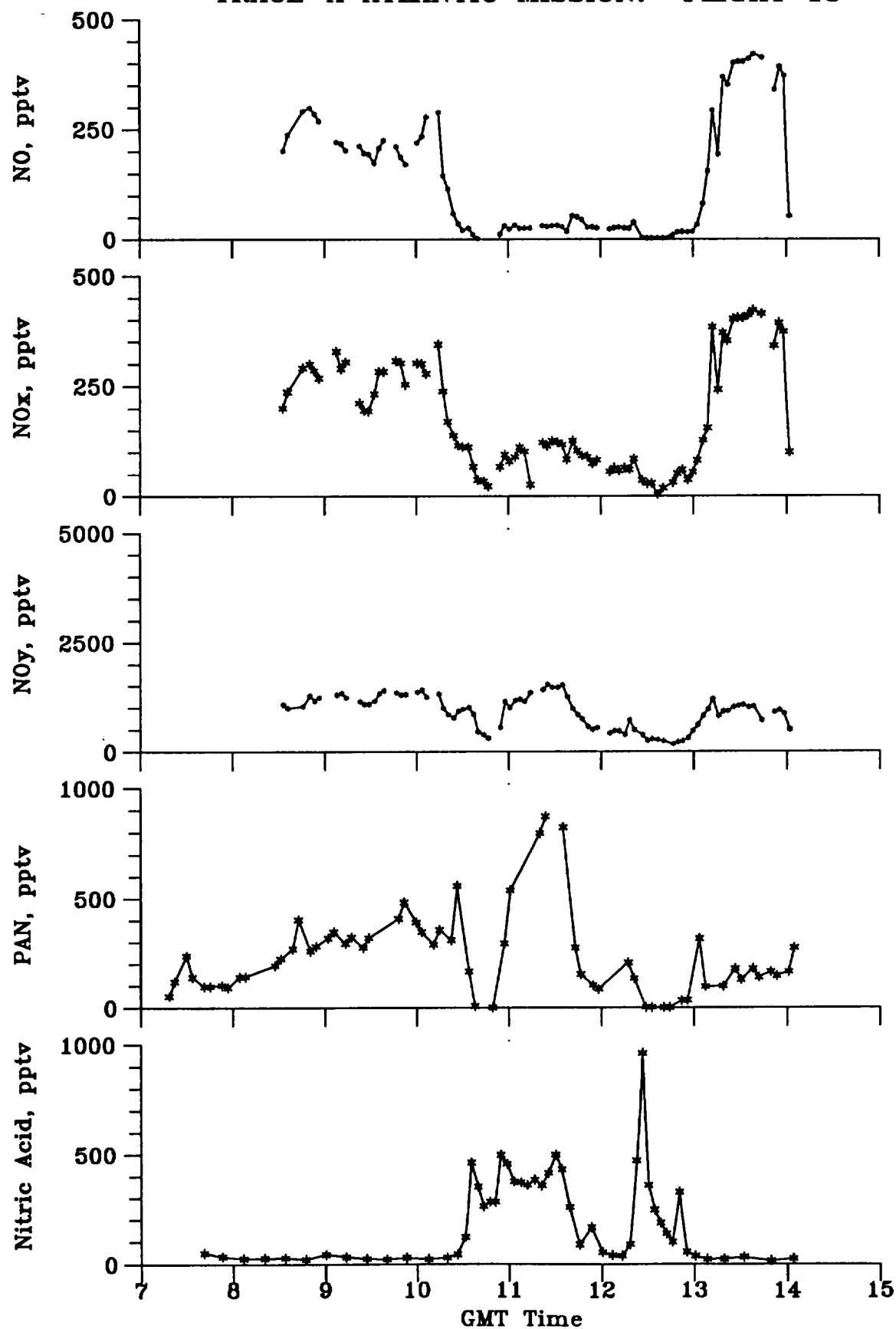


Figure A13.3

TRACE-A ATLANTIC MISSION: FLIGHT 13

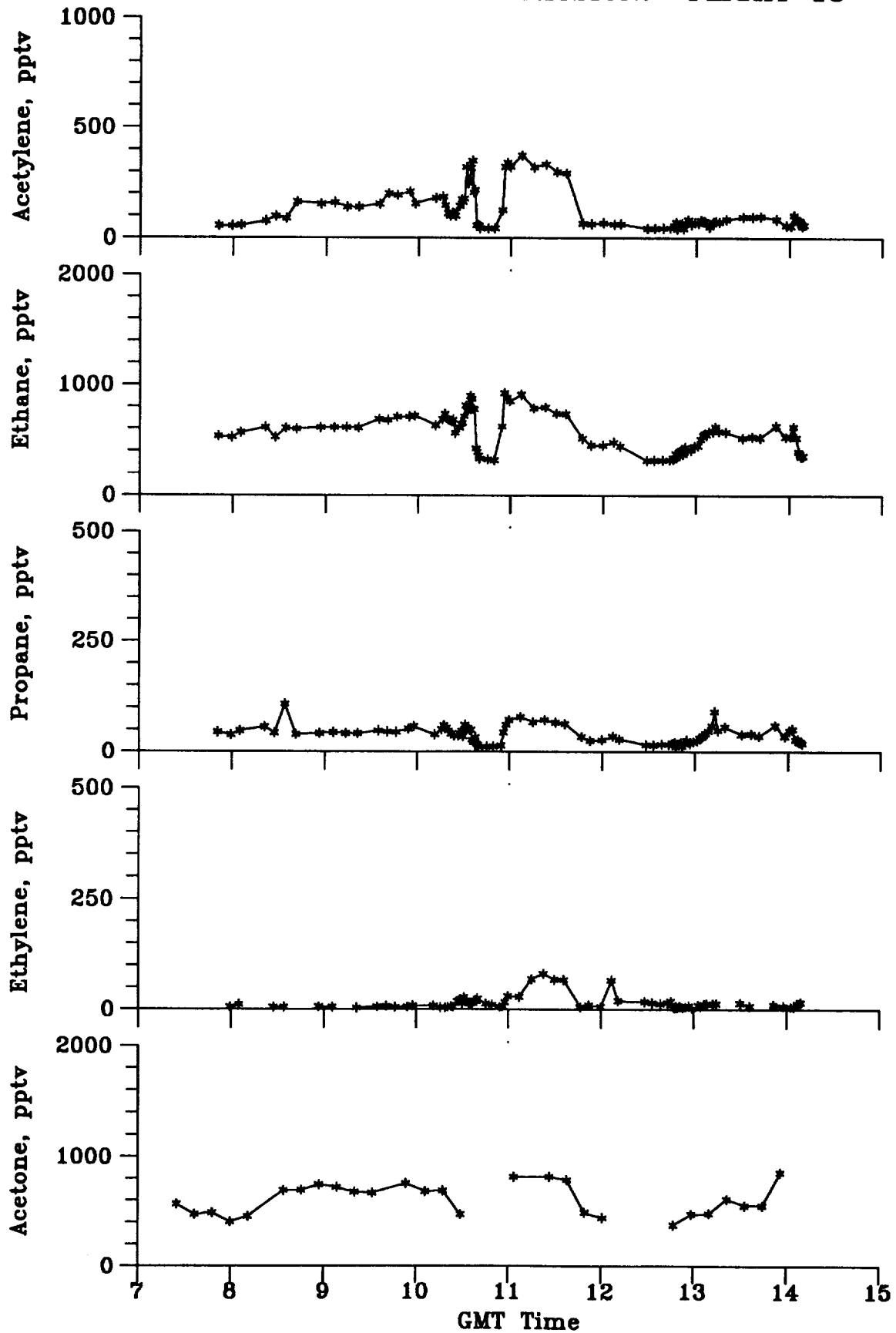


Figure A13.4

TRACE-A ATLANTIC MISSION: FLIGHT 13

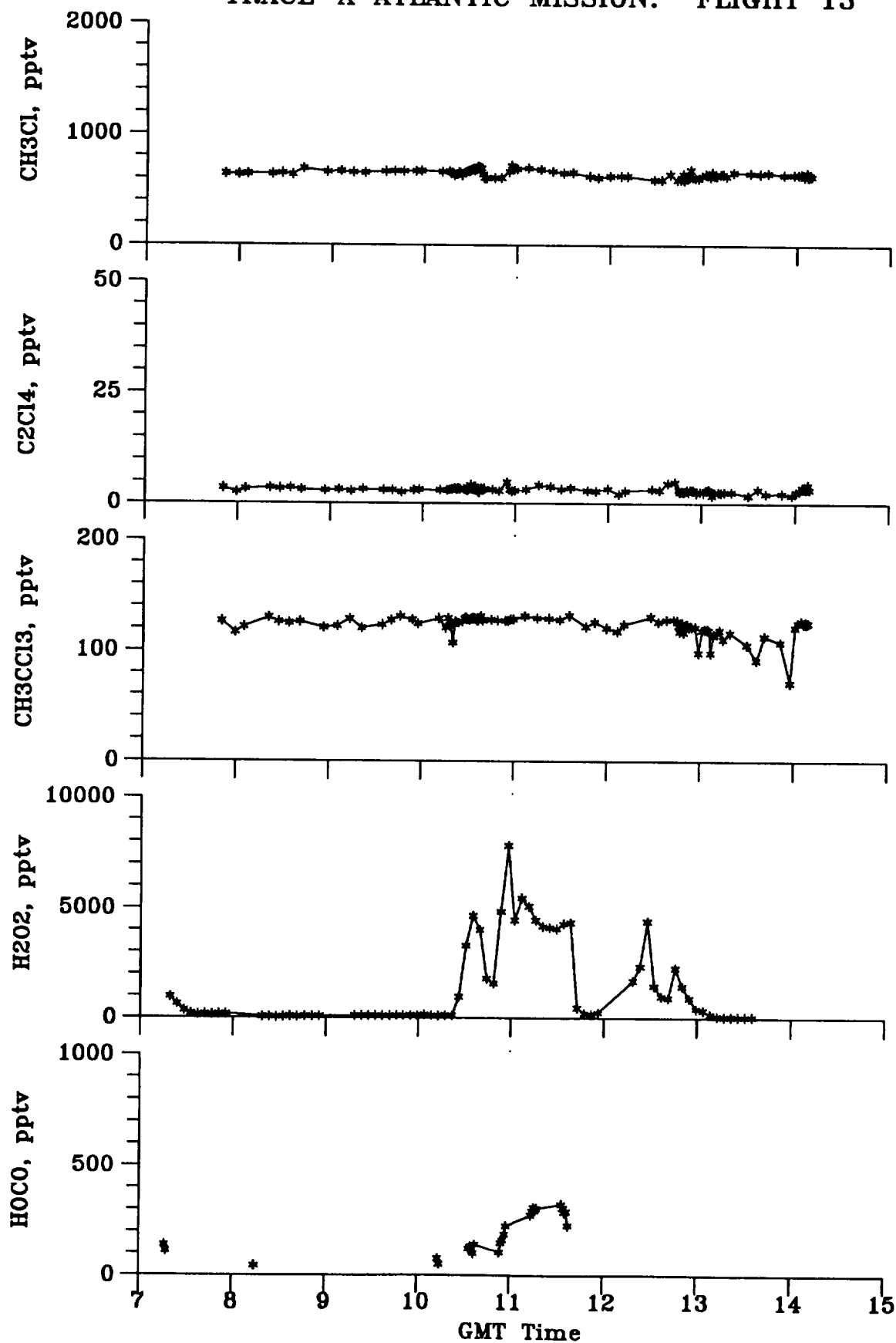


Figure A13.5

TRACE-A ATLANTIC MISSION: FLIGHT 13

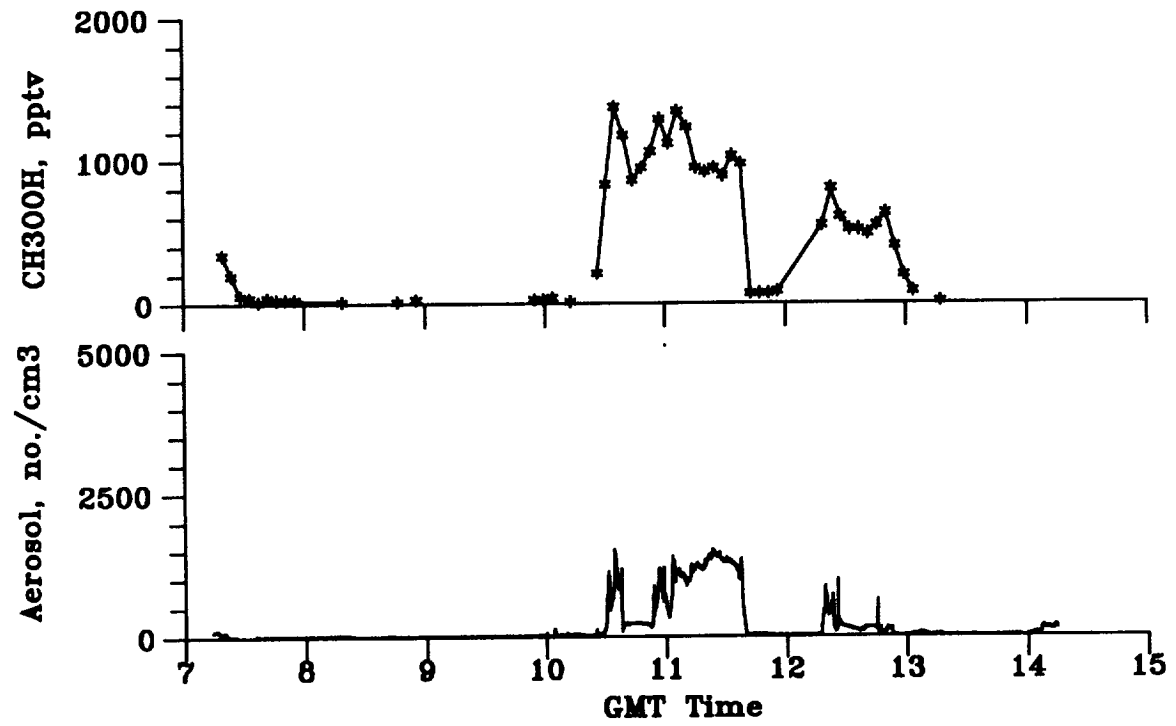
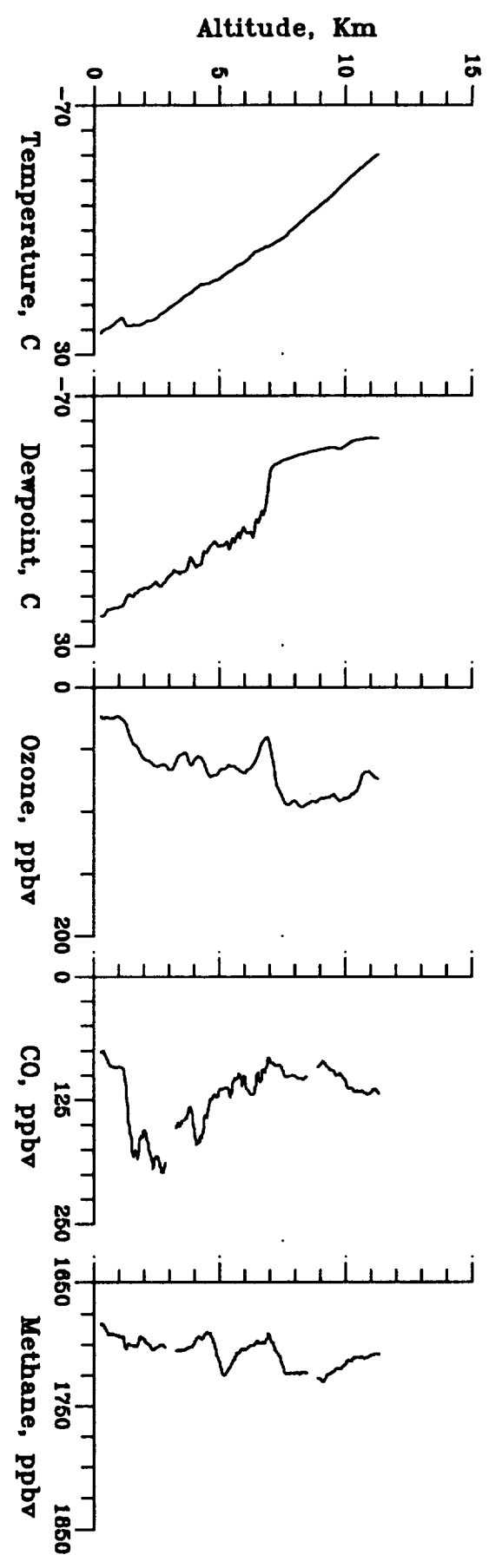
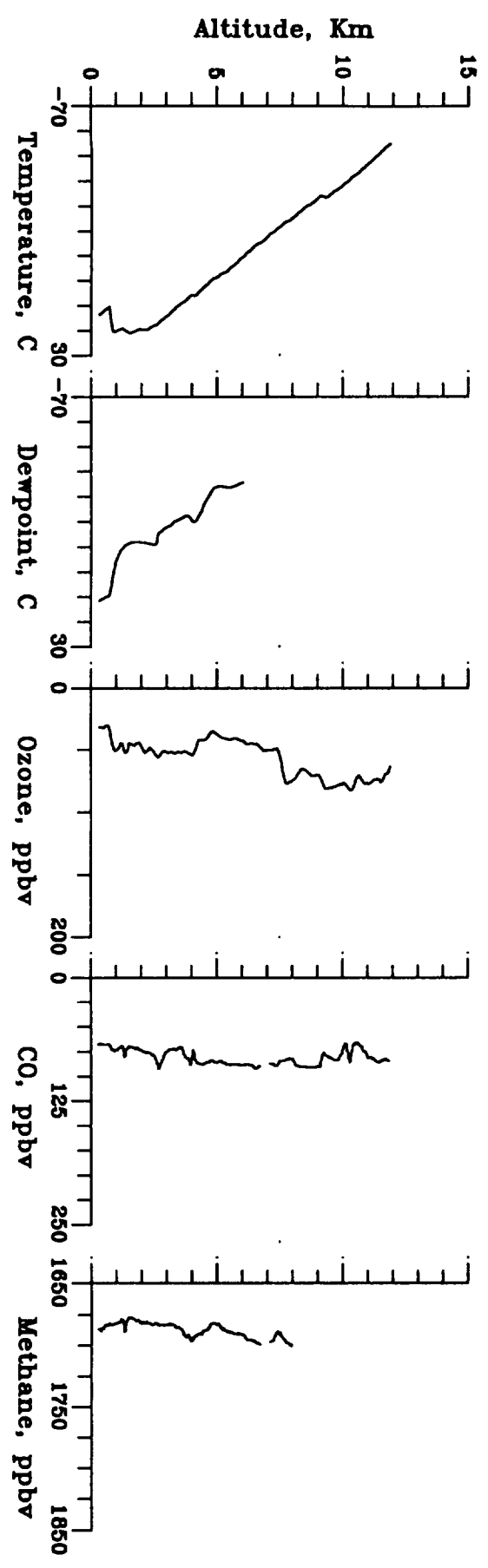


Figure A13.6

TRACE (A) ATLANTIC MISSION: FLIGHT 13 PROFILE AT 1030 GMT



TRACE (A) ATLANTIC MISSION: FLIGHT 13 PROFILE AT 1300 GMT



TRACE-A ATLANTIC MISSION: FLIGHT 14

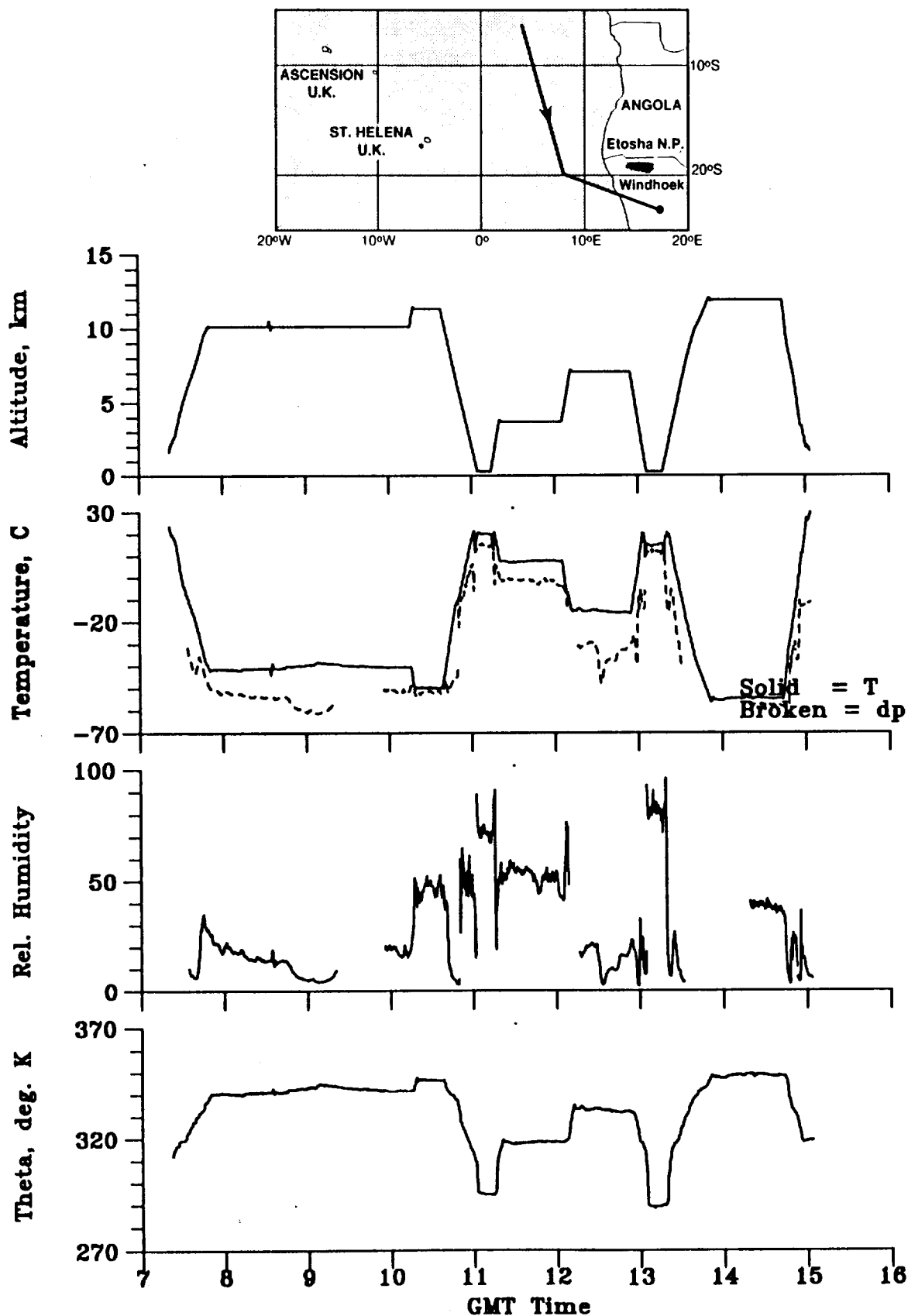


Figure A14.1

TRACE-A ATLANTIC MISSION: FLIGHT 14

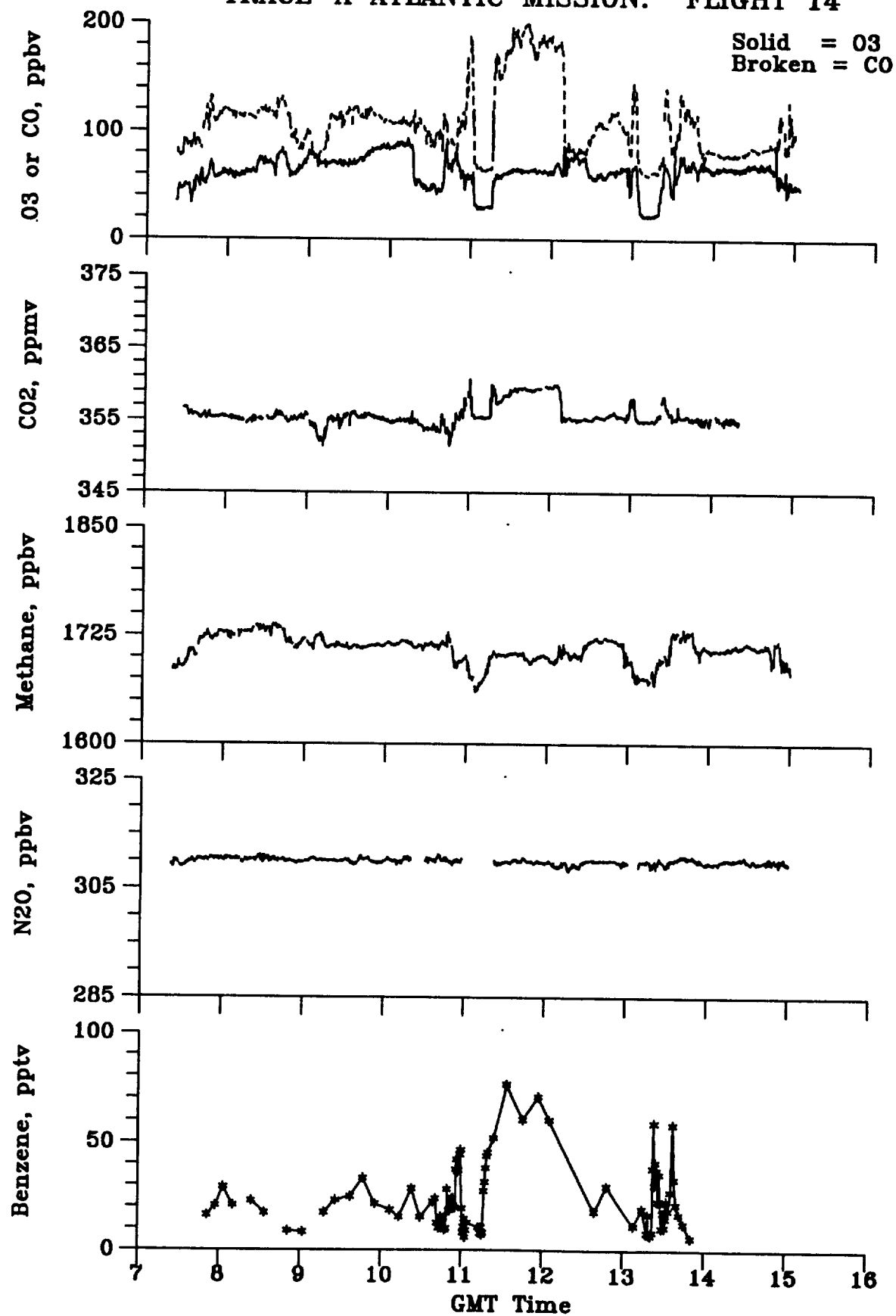


Figure A14.2

TRACE-A ATLANTIC MISSION: FLIGHT 14

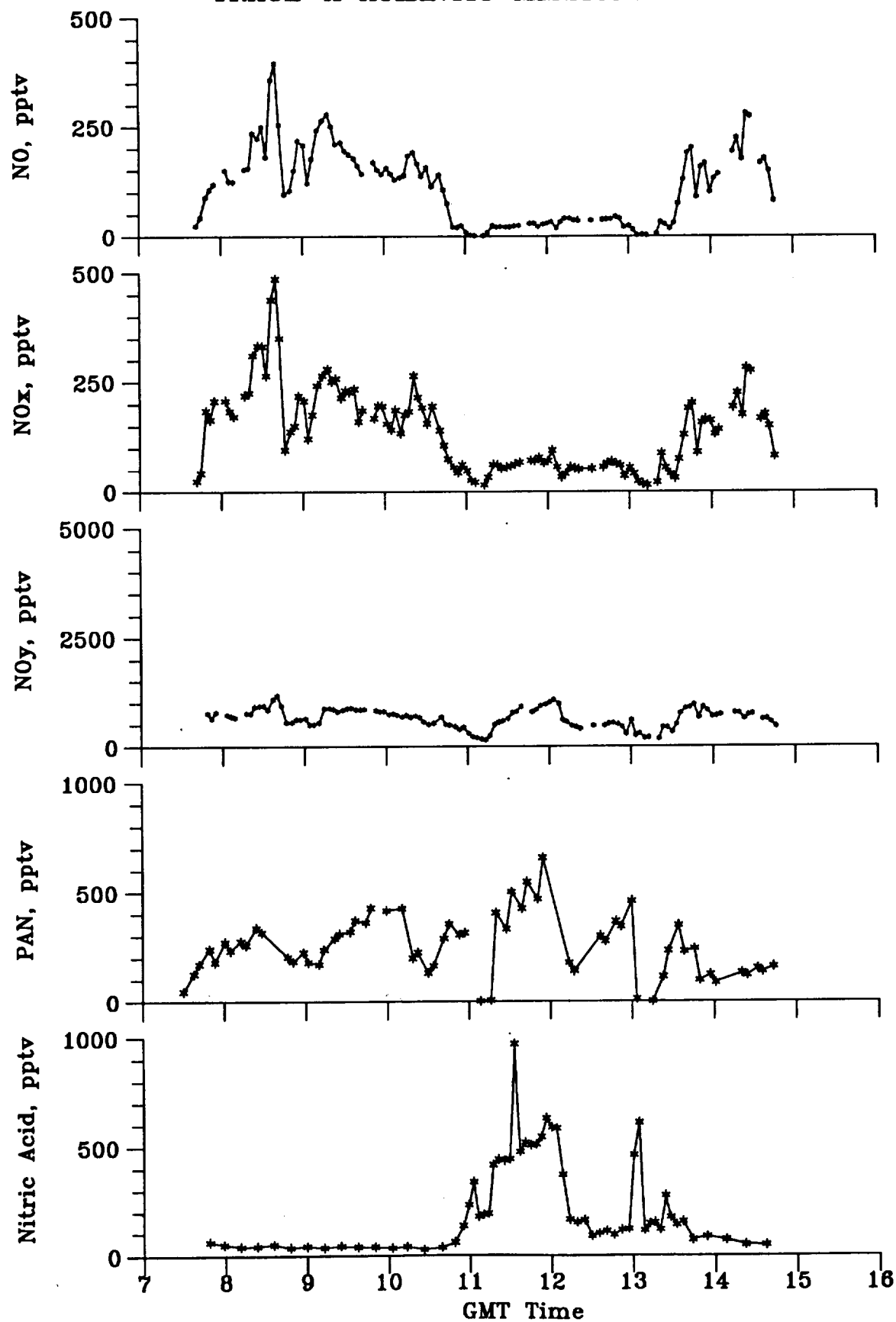


Figure A14.3

TRACE-A ATLANTIC MISSION: FLIGHT 14

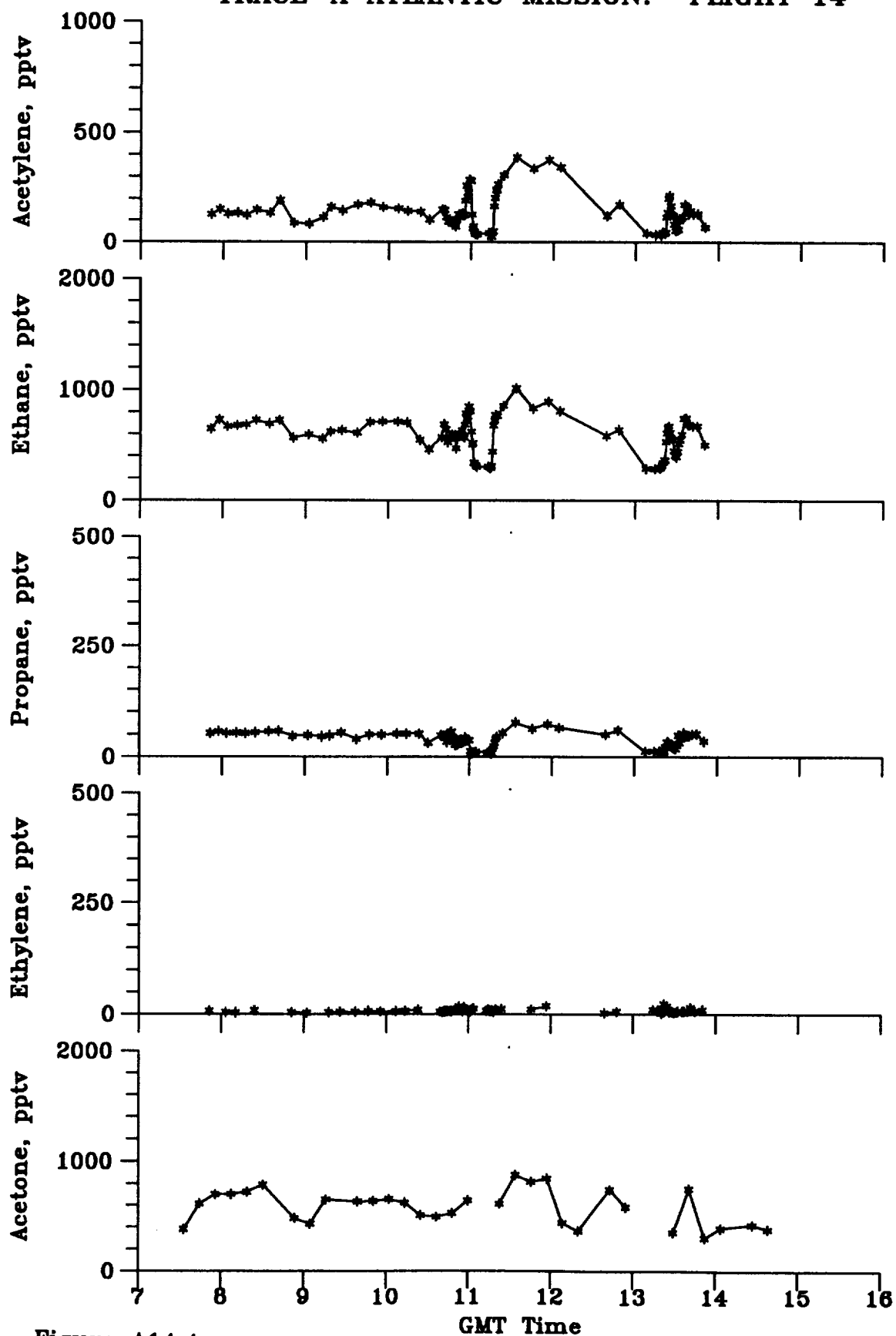


Figure A14.4

TRACE-A ATLANTIC MISSION: FLIGHT 14

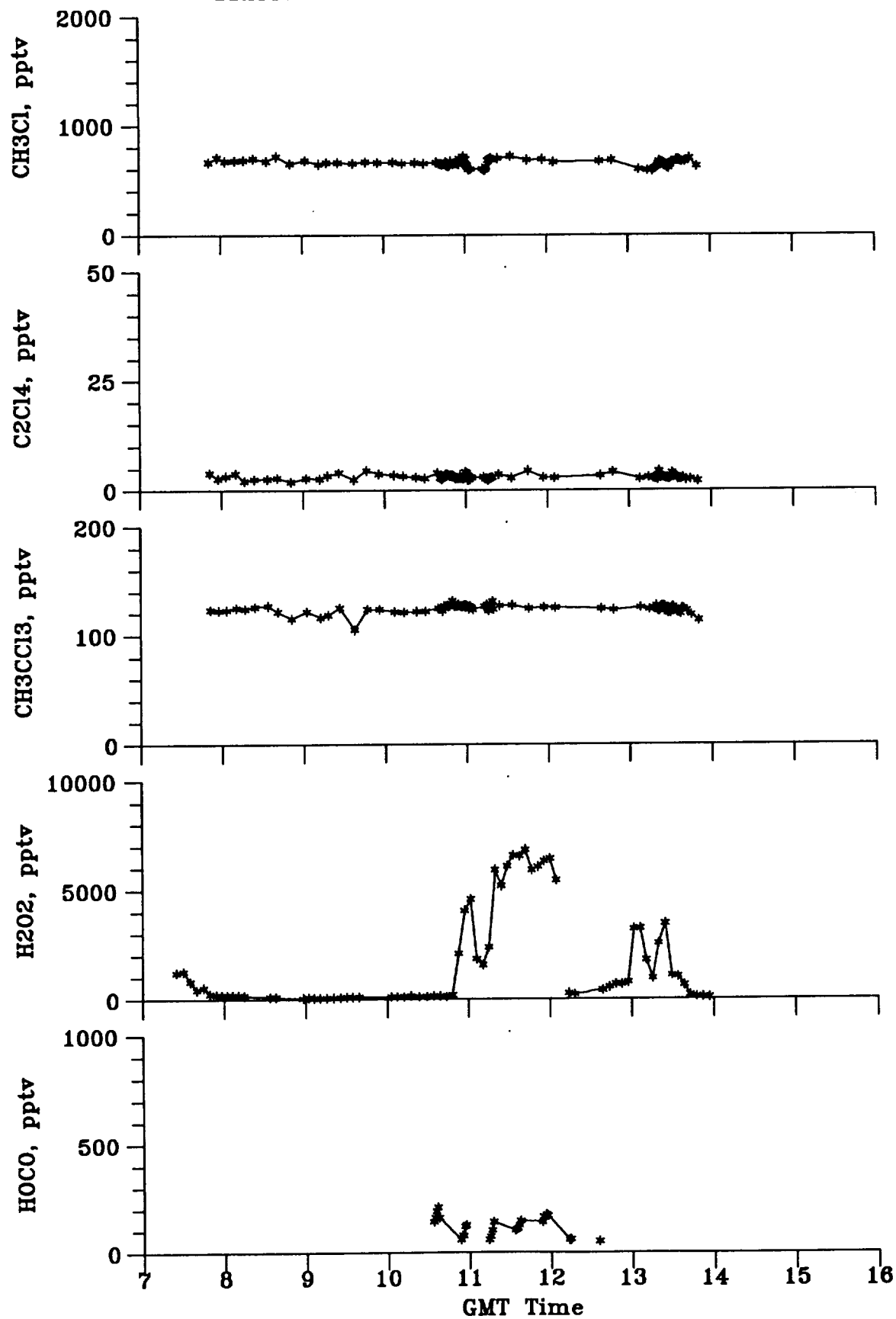


Figure A14.5

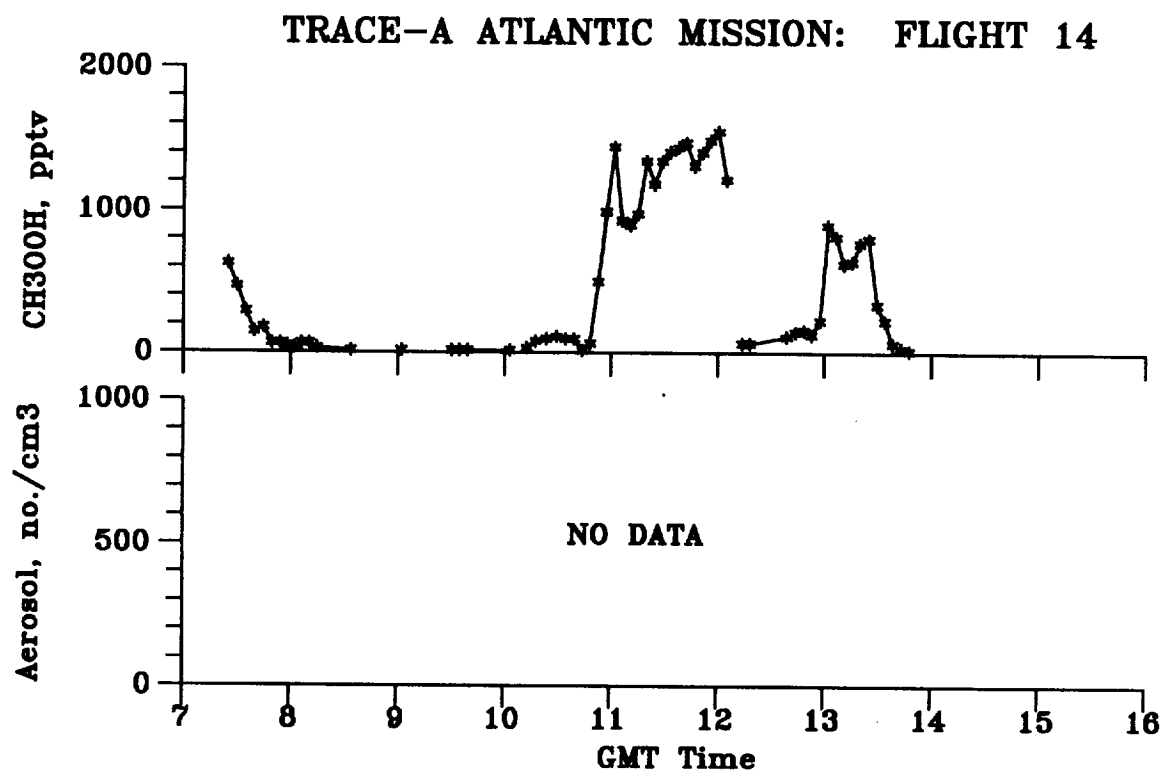
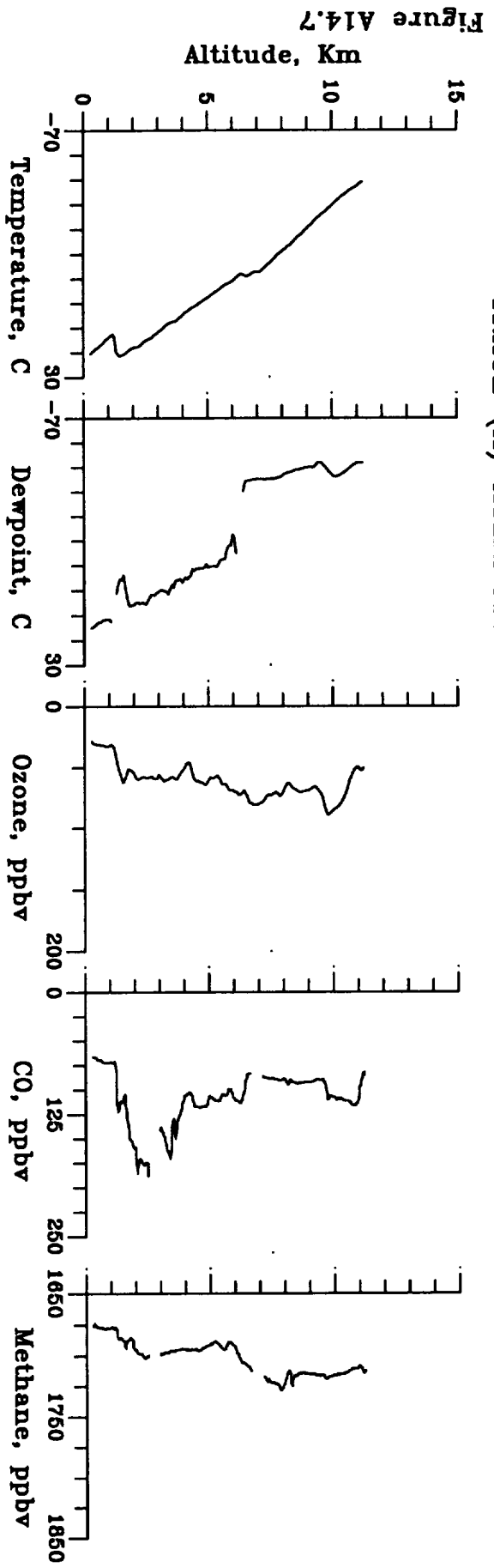
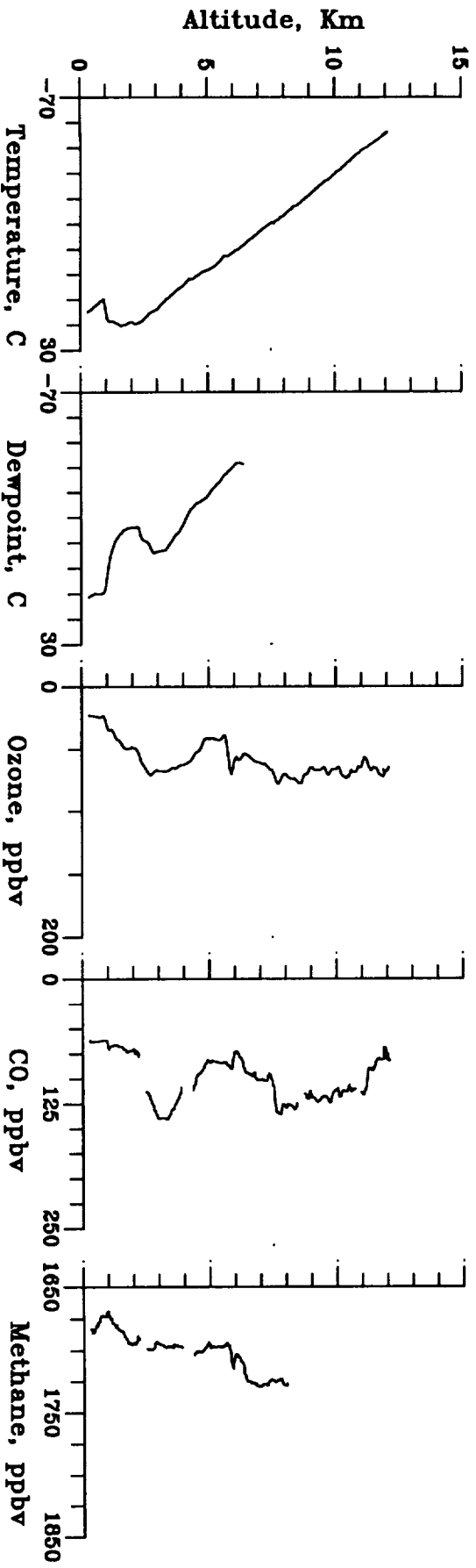


Figure A14.6

TRACE (A) ATLANTIC MISSION: FLIGHT 14 PROFILE AT 1045 GMT



TRACE (A) ATLANTIC MISSION: FLIGHT 14 PROFILE AT 1330 GMT



TRACE-A ATLANTIC MISSION: FLIGHT 15

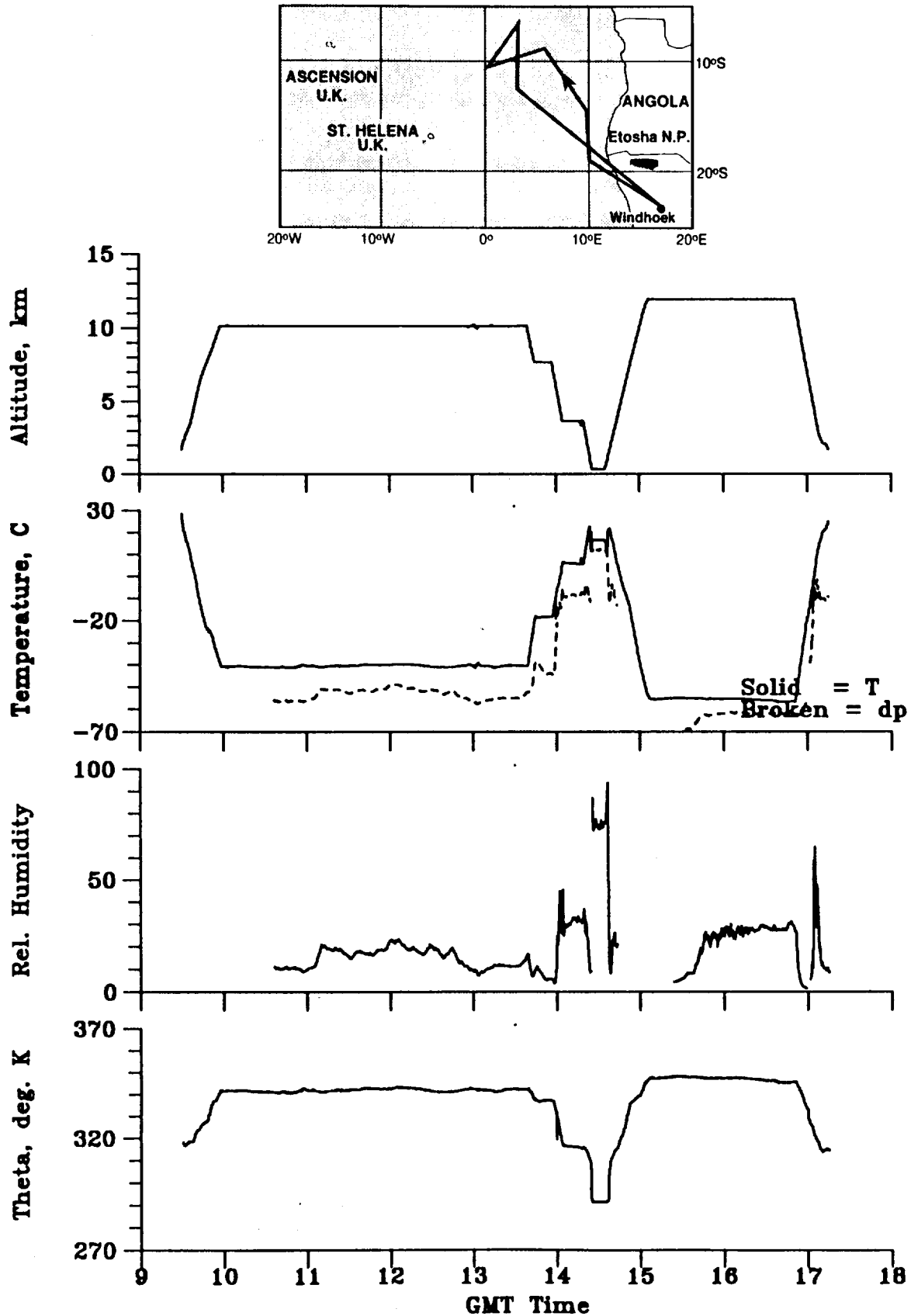


Figure A15.1

TRACE-A ATLANTIC MISSION: FLIGHT 15

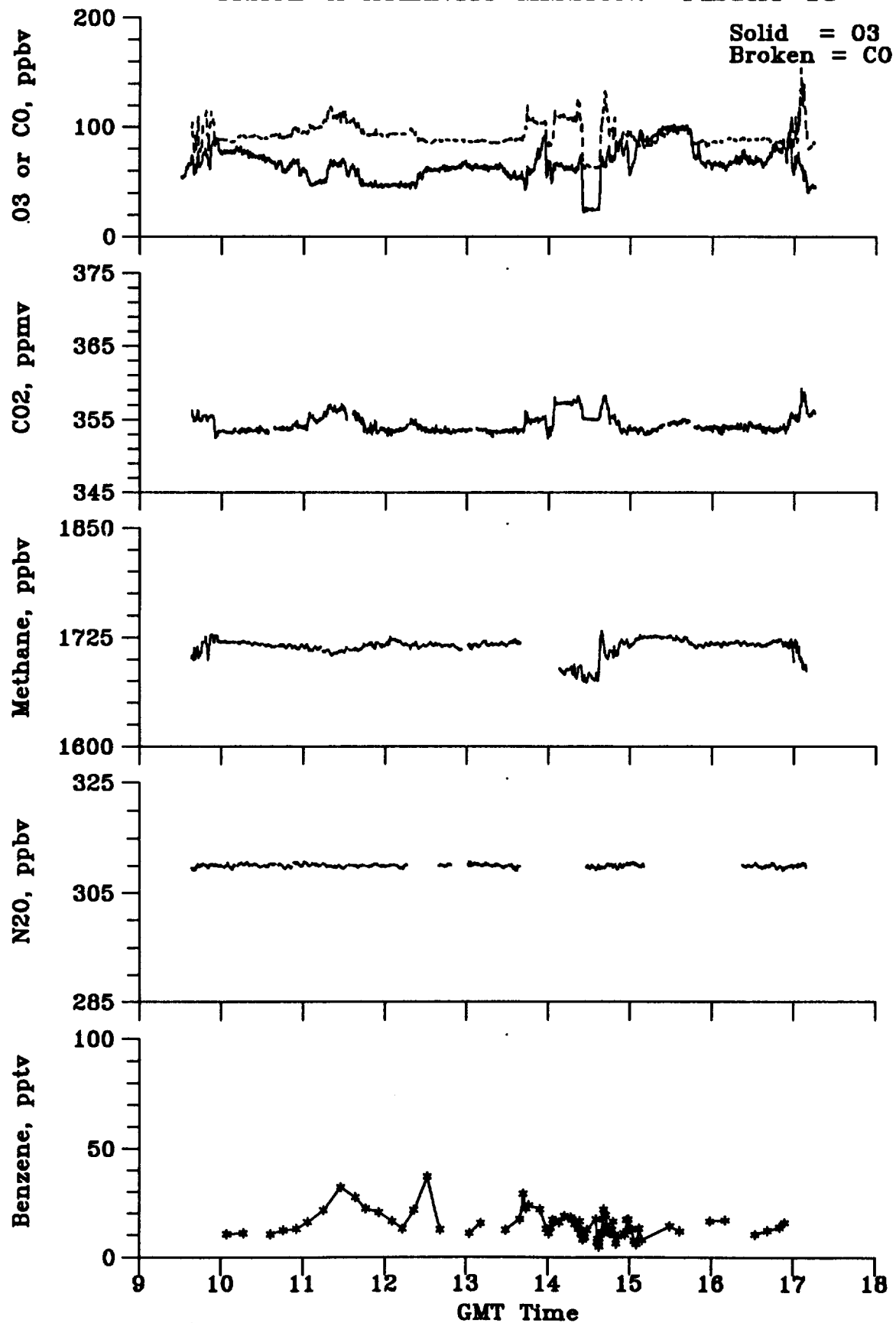


Figure A15.2

TRACE-A ATLANTIC MISSION: FLIGHT 15

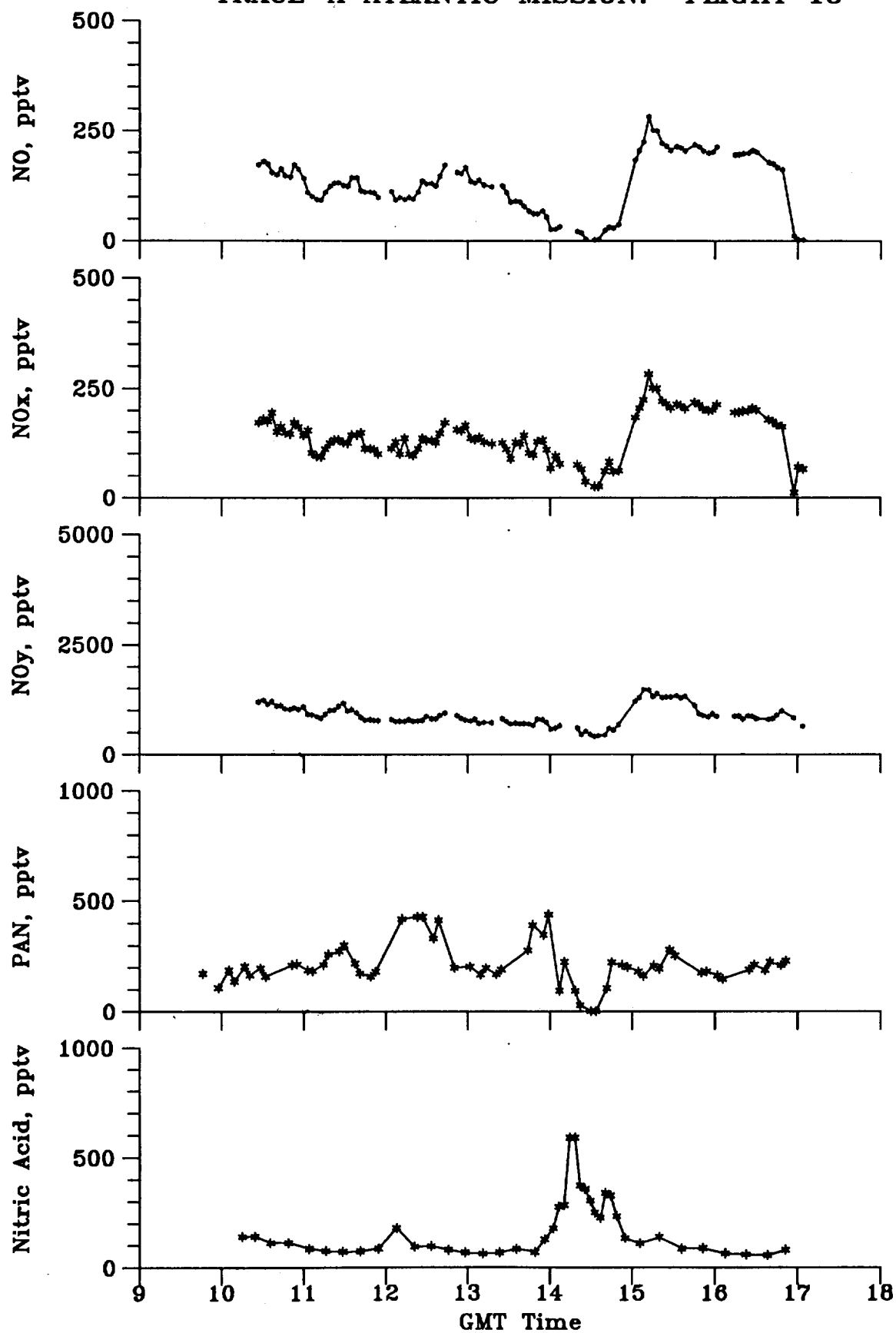


Figure A15.3

TRACE-A ATLANTIC MISSION: FLIGHT 15

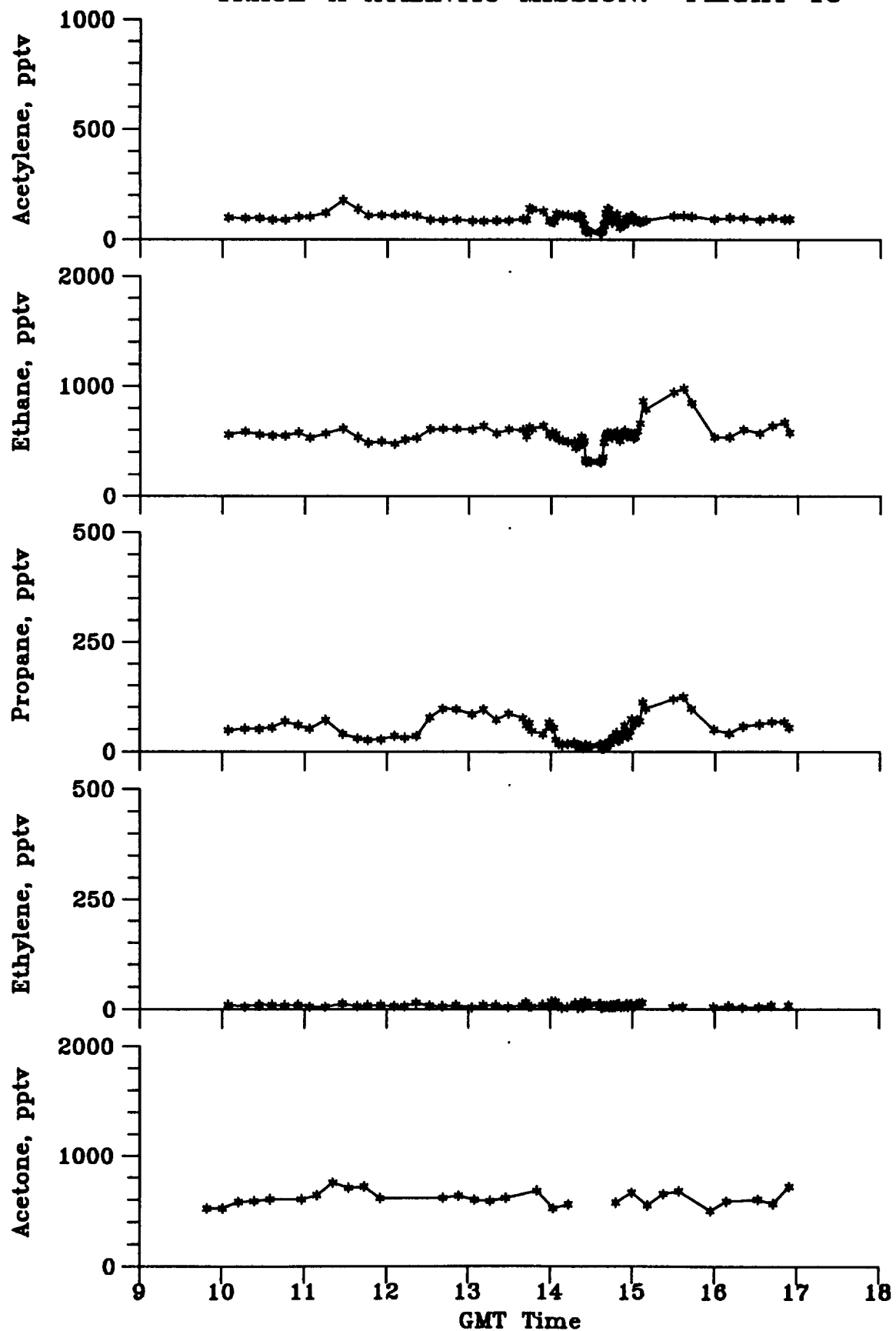


Figure A15.4

TRACE-A ATLANTIC MISSION: FLIGHT 15

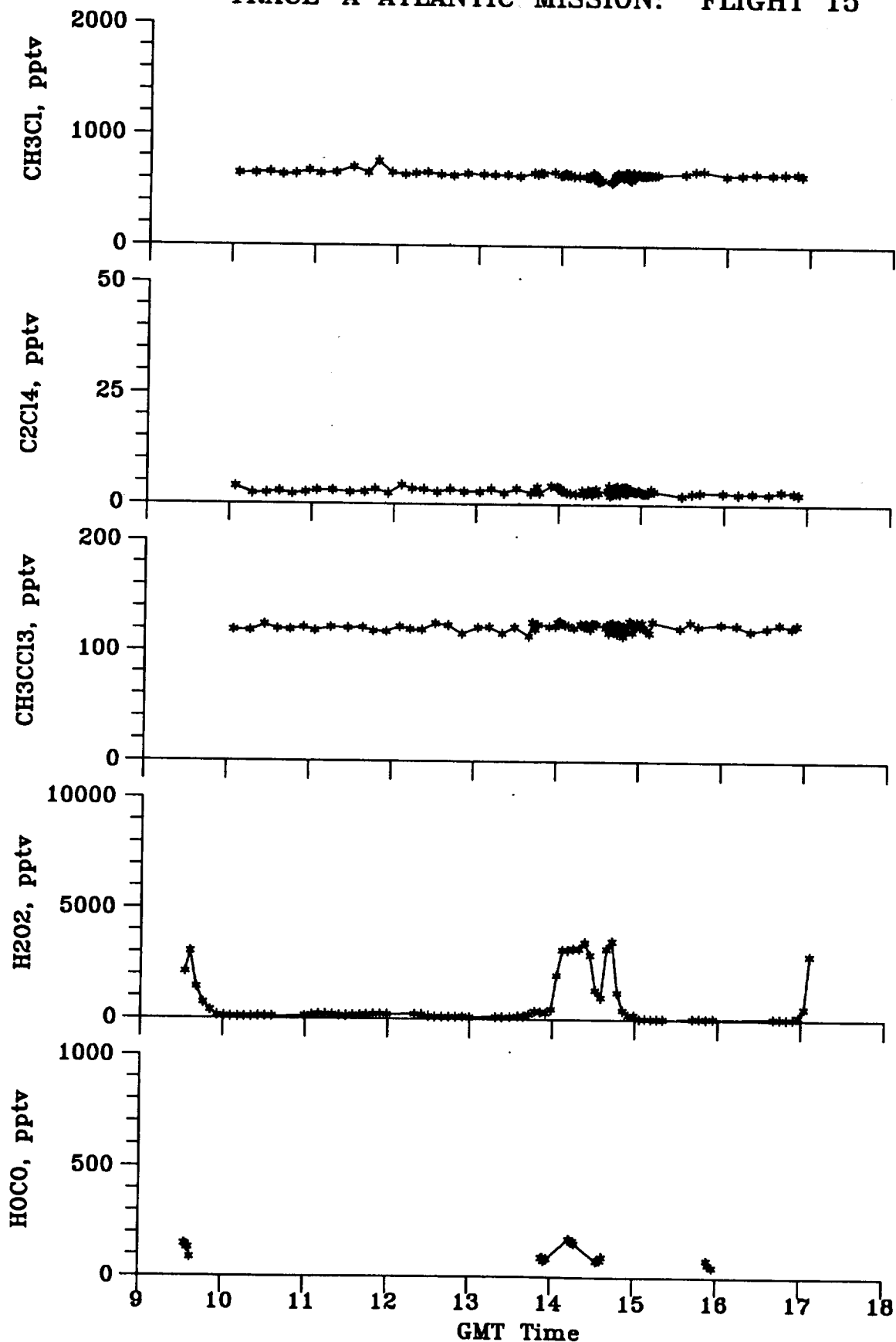


Figure A15.5

TRACE-A ATLANTIC MISSION: FLIGHT 15

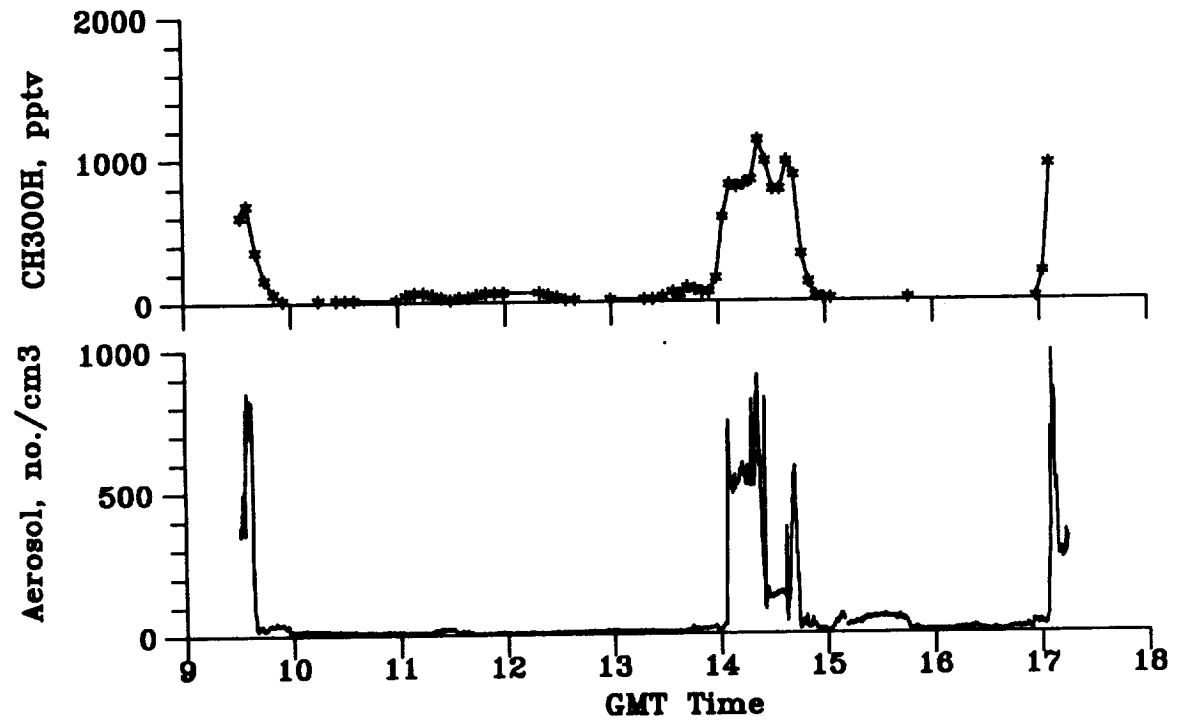


Figure A15.6

TRACE (A) ATLANTIC MISSION: FLIGHT 15 PROFILE AT 0945 GMT

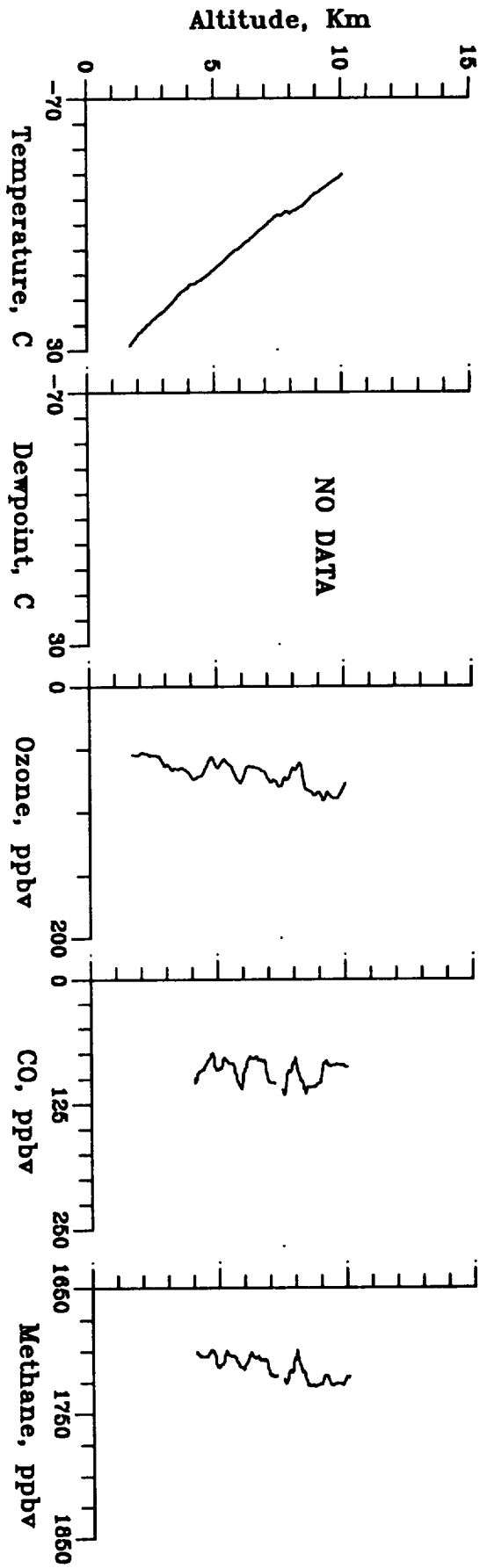
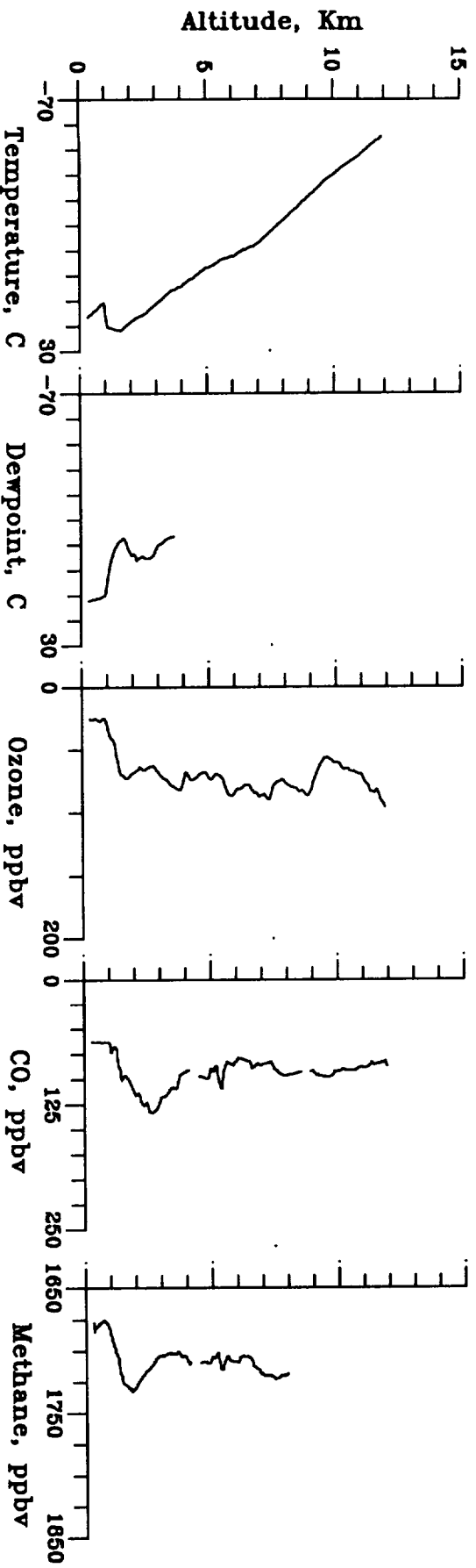


Figure A15.7

125

TRACE (A) ATLANTIC MISSION: FLIGHT 15 PROFILE AT 1500 GMT



125

TRACE-A ATLANTIC MISSION: FLIGHT 16

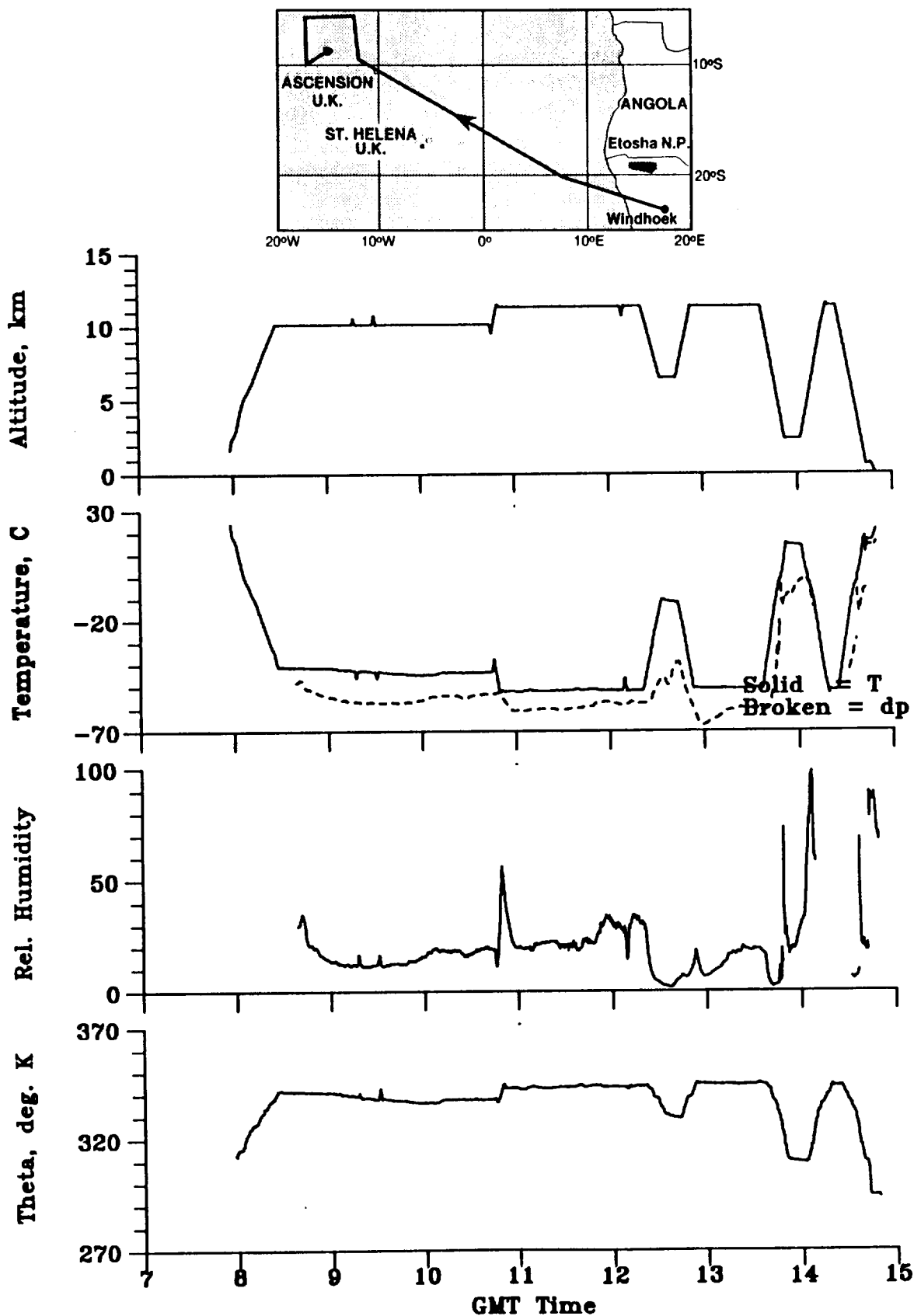


Figure A16.1

TRACE-A ATLANTIC MISSION: FLIGHT 16

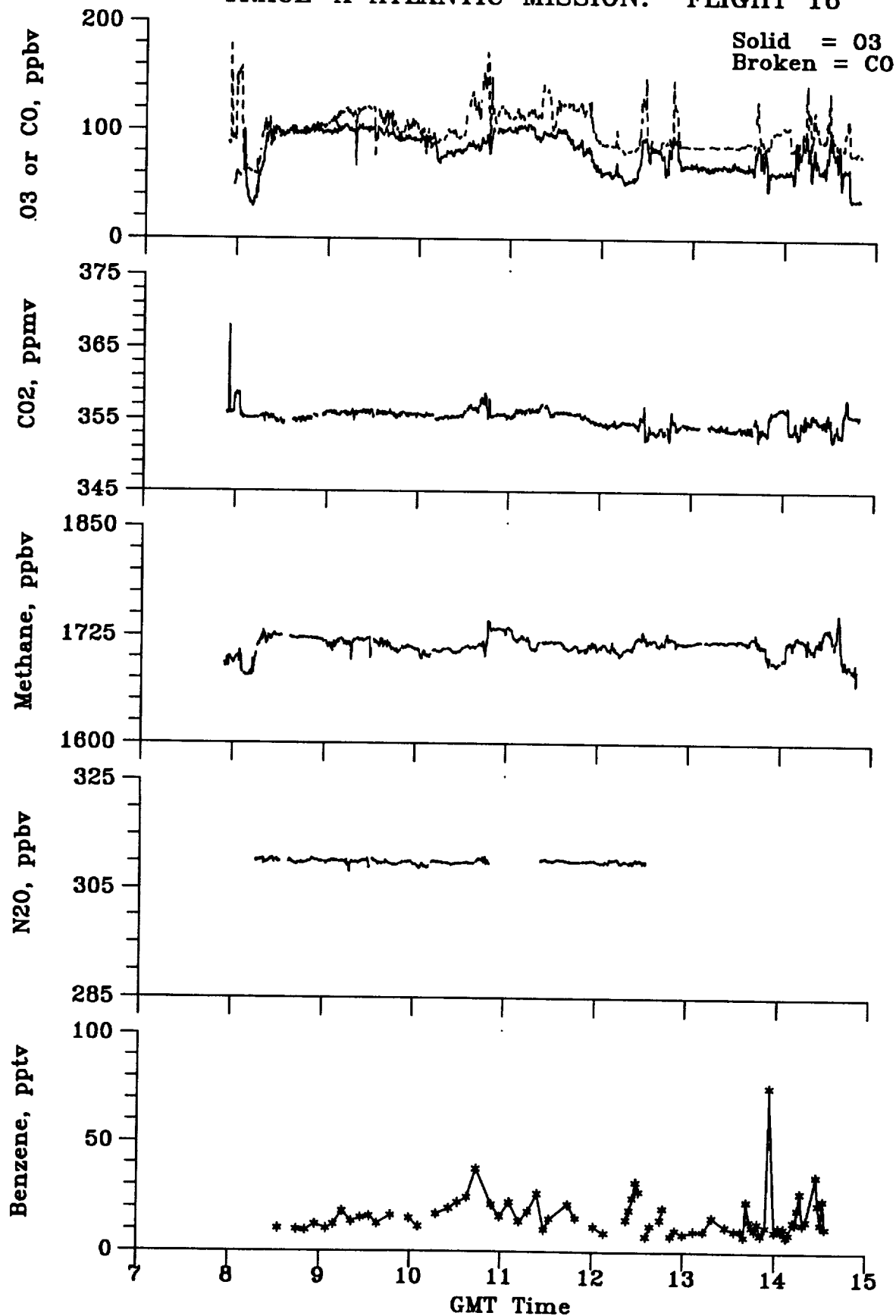


Figure A16.2

TRACE-A ATLANTIC MISSION: FLIGHT 16

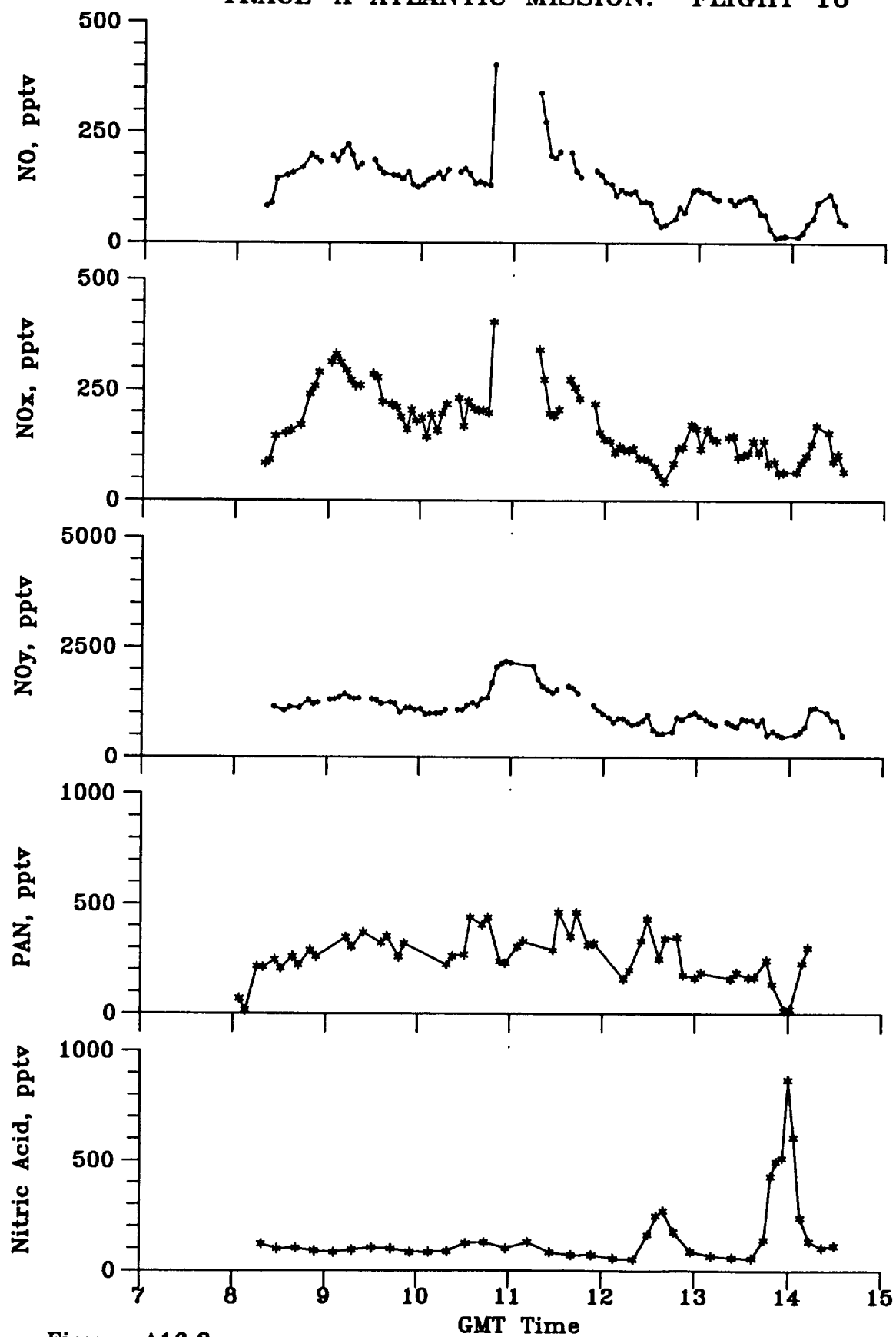


Figure A16.3

TRACE-A ATLANTIC MISSION: FLIGHT 16

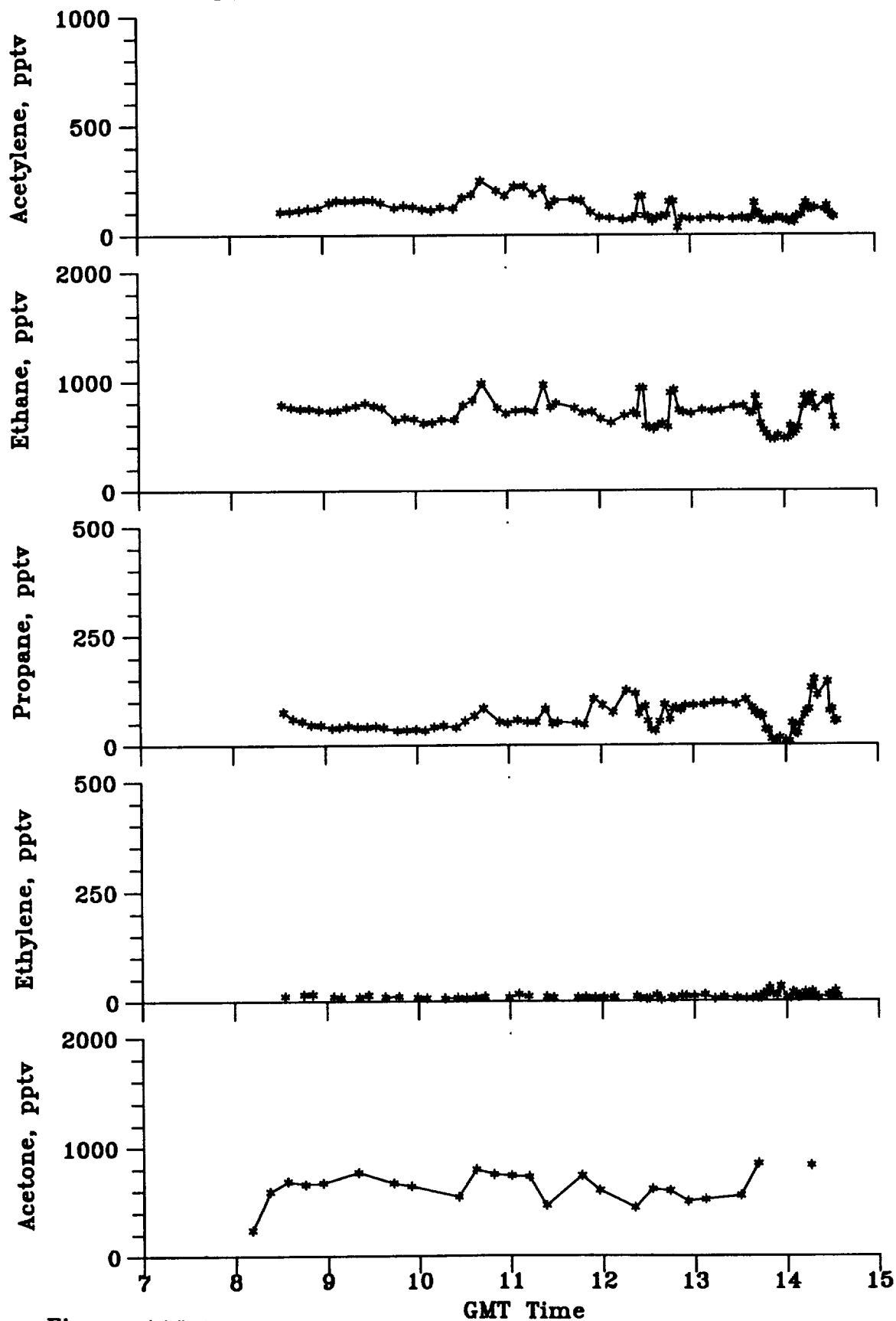


Figure A16.4

TRACE-A ATLANTIC MISSION: FLIGHT 16

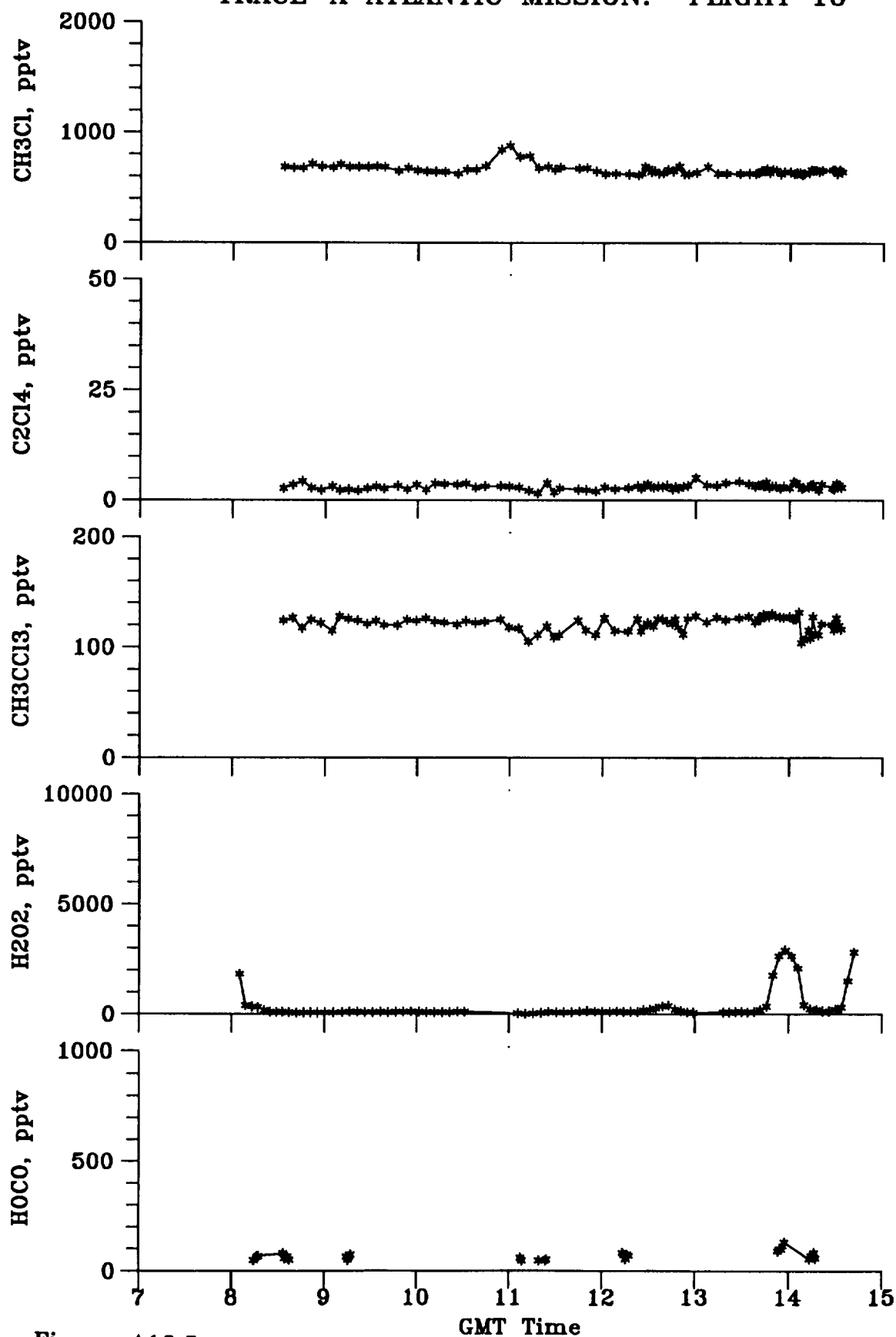


Figure A16.5

TRACE-A ATLANTIC MISSION: FLIGHT 16

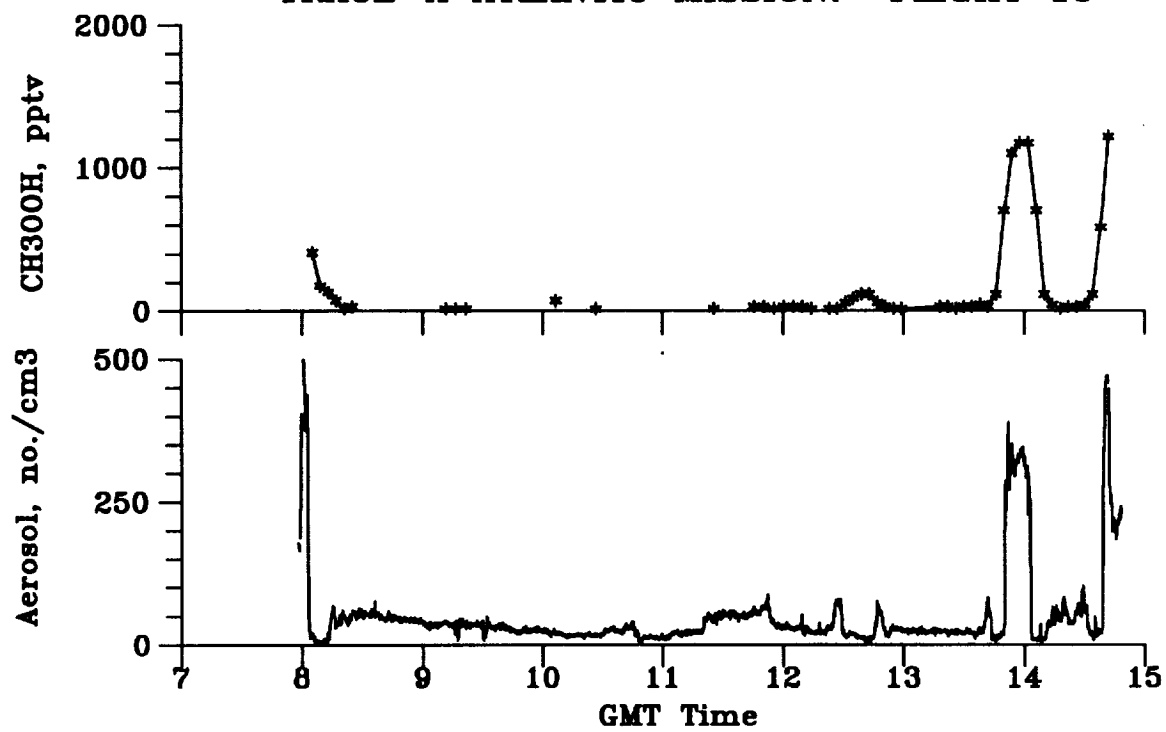
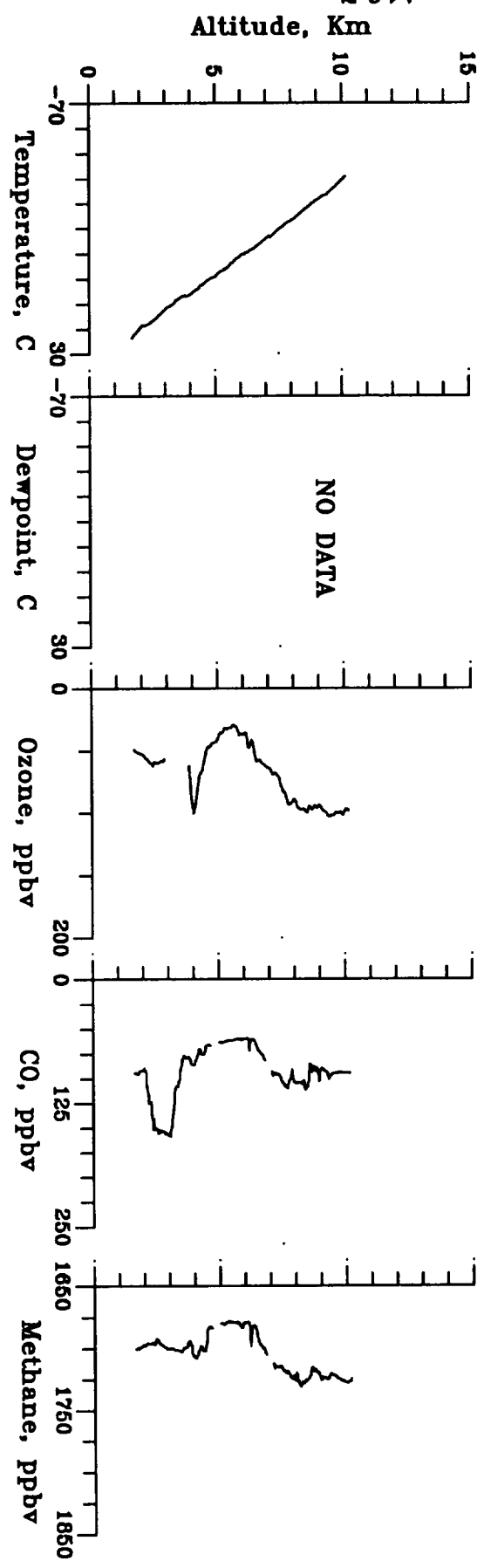
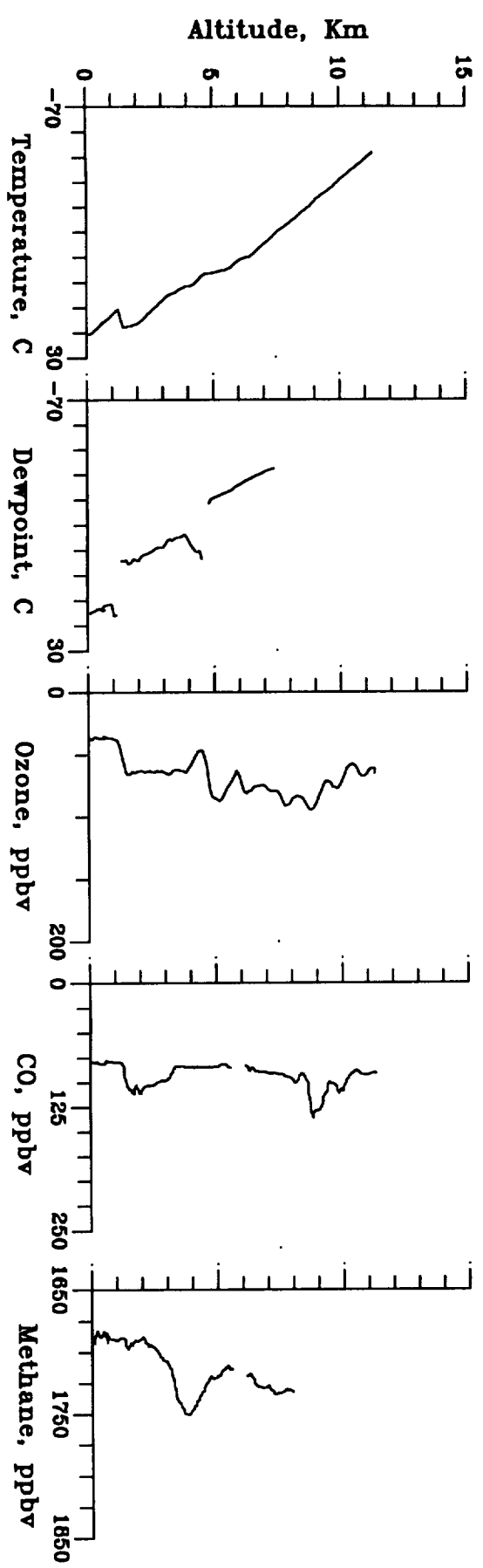


Figure A16.6

TRACE (A) ATLANTIC MISSION: FLIGHT 16 PROFILE AT 0815 GMT



TRACE (A) ATLANTIC MISSION: FLIGHT 16 PROFILE AT 1430 GMT



TRACE-A ATLANTIC MISSION: FLIGHT 17

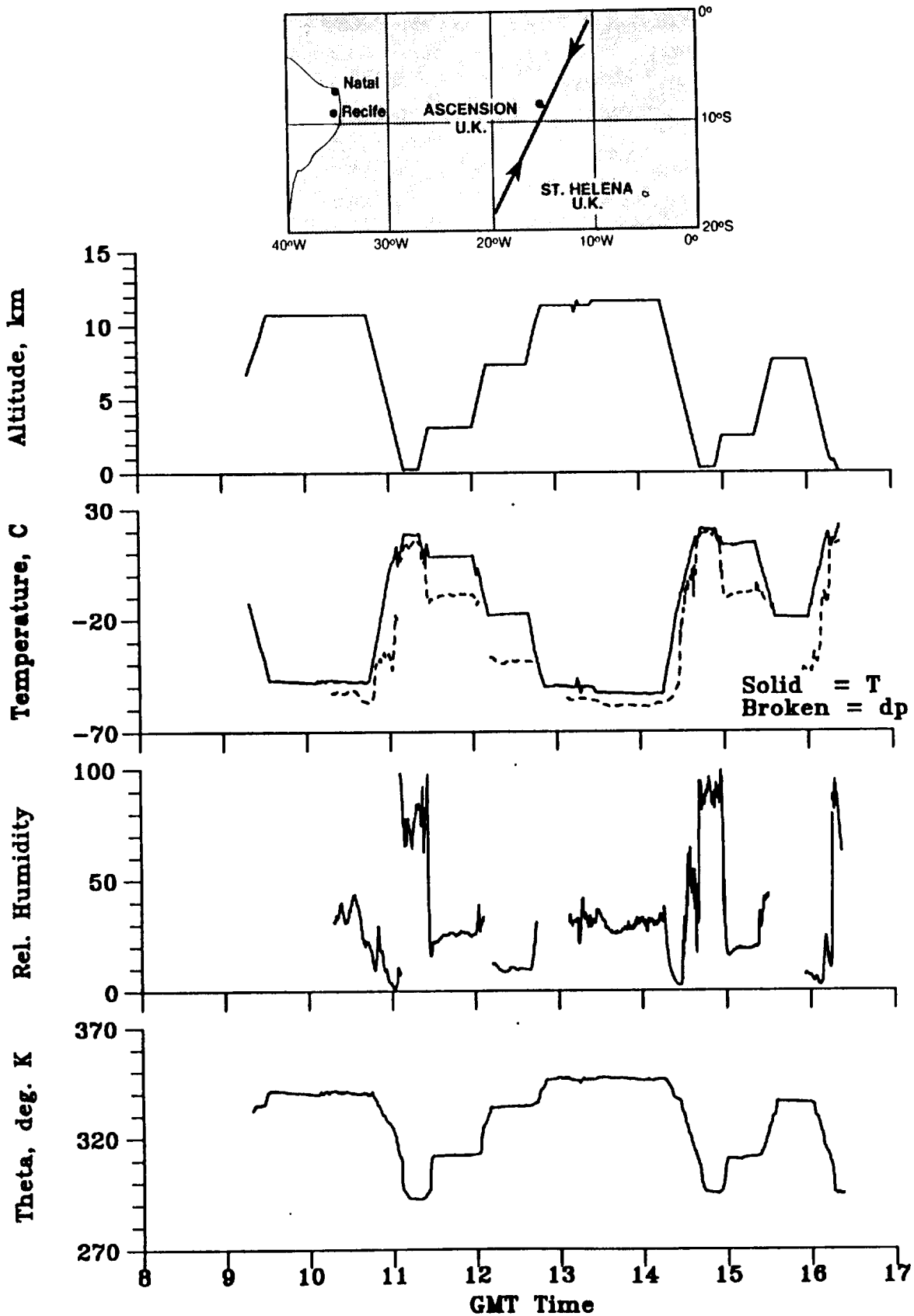


Figure A17.1

TRACE-A ATLANTIC MISSION: FLIGHT 17

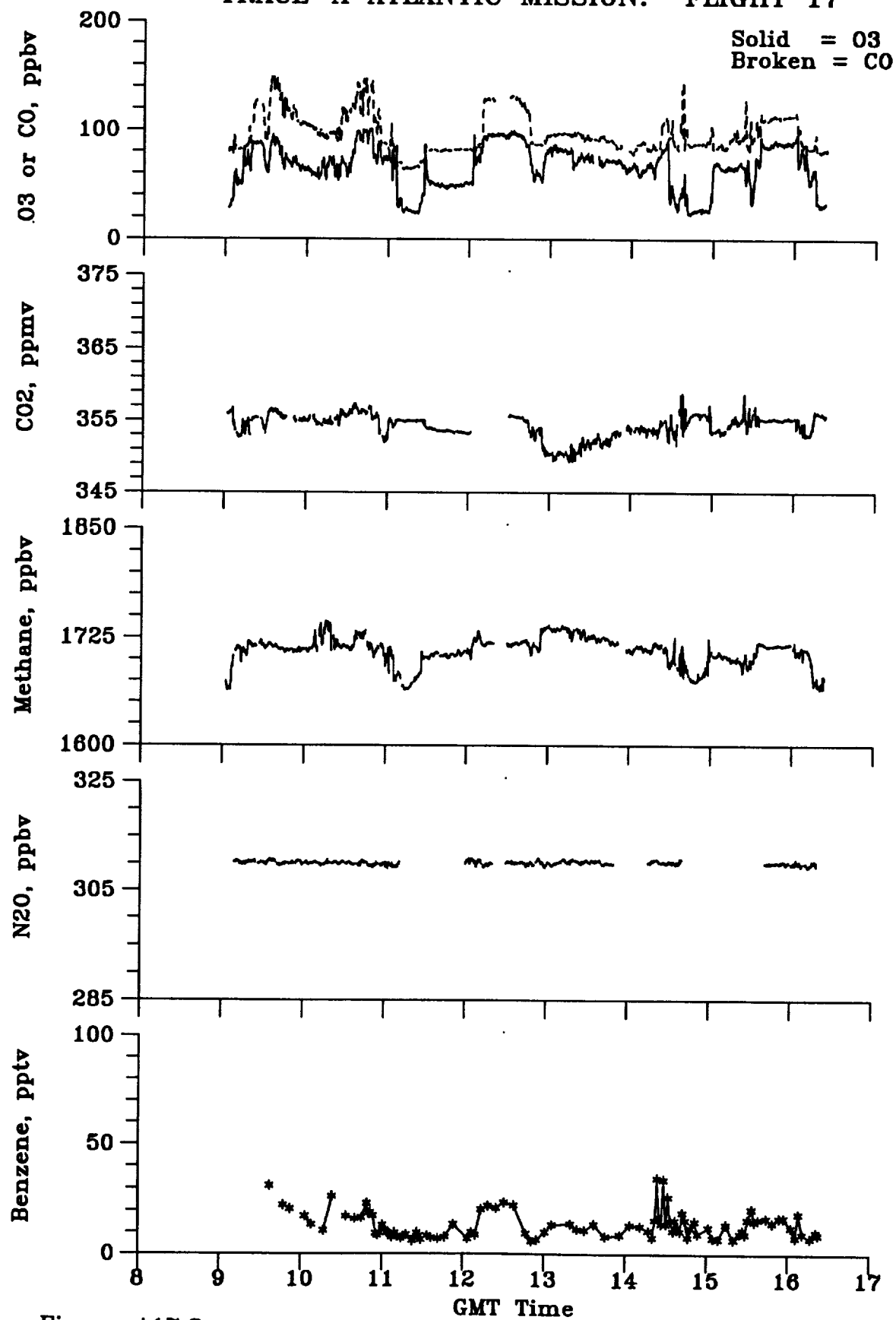


Figure A17.2

TRACE-A ATLANTIC MISSION: FLIGHT 17

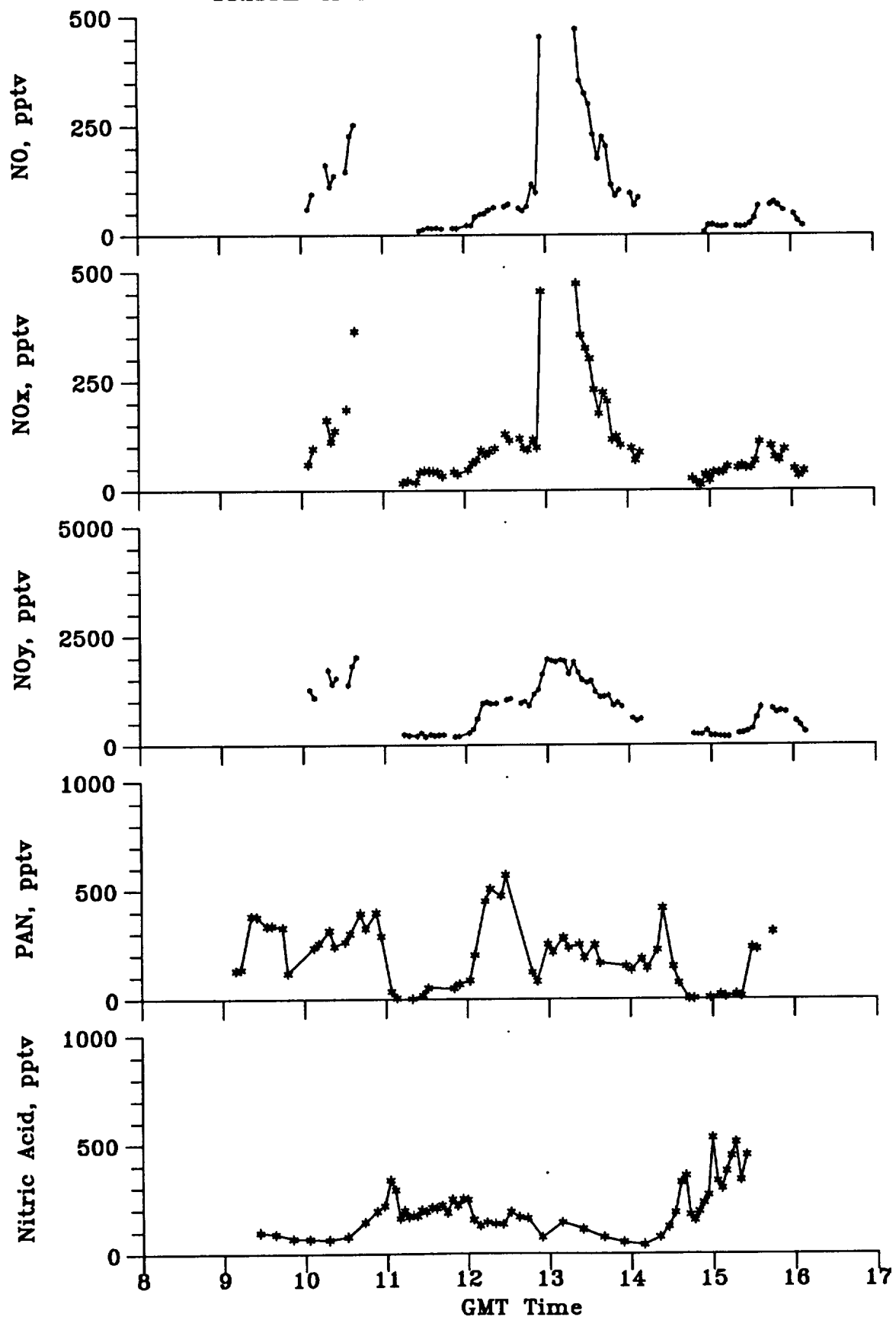


Figure A17.3

TRACE-A ATLANTIC MISSION: FLIGHT 17

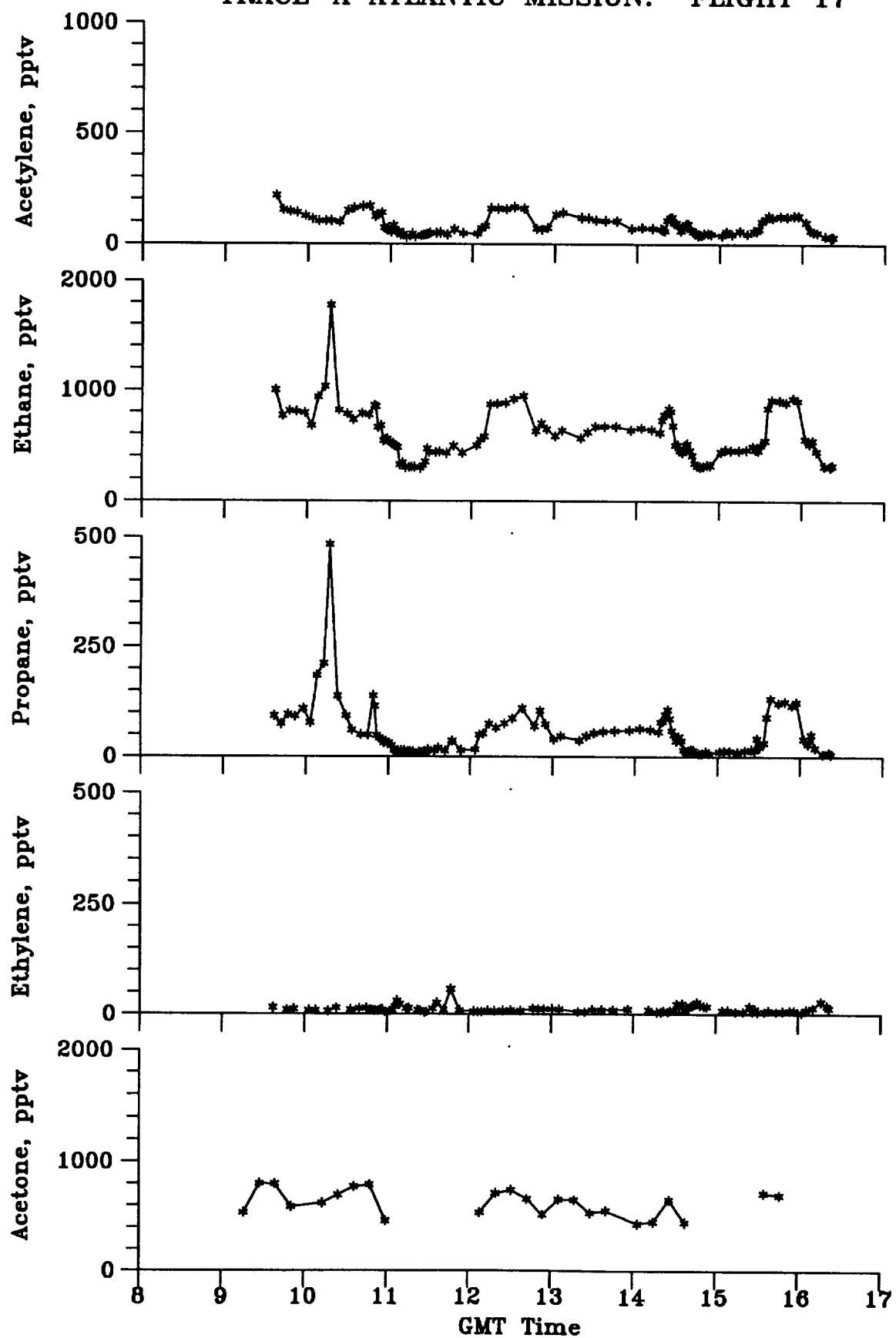


Figure A17.4

TRACE-A ATLANTIC MISSION: FLIGHT 17

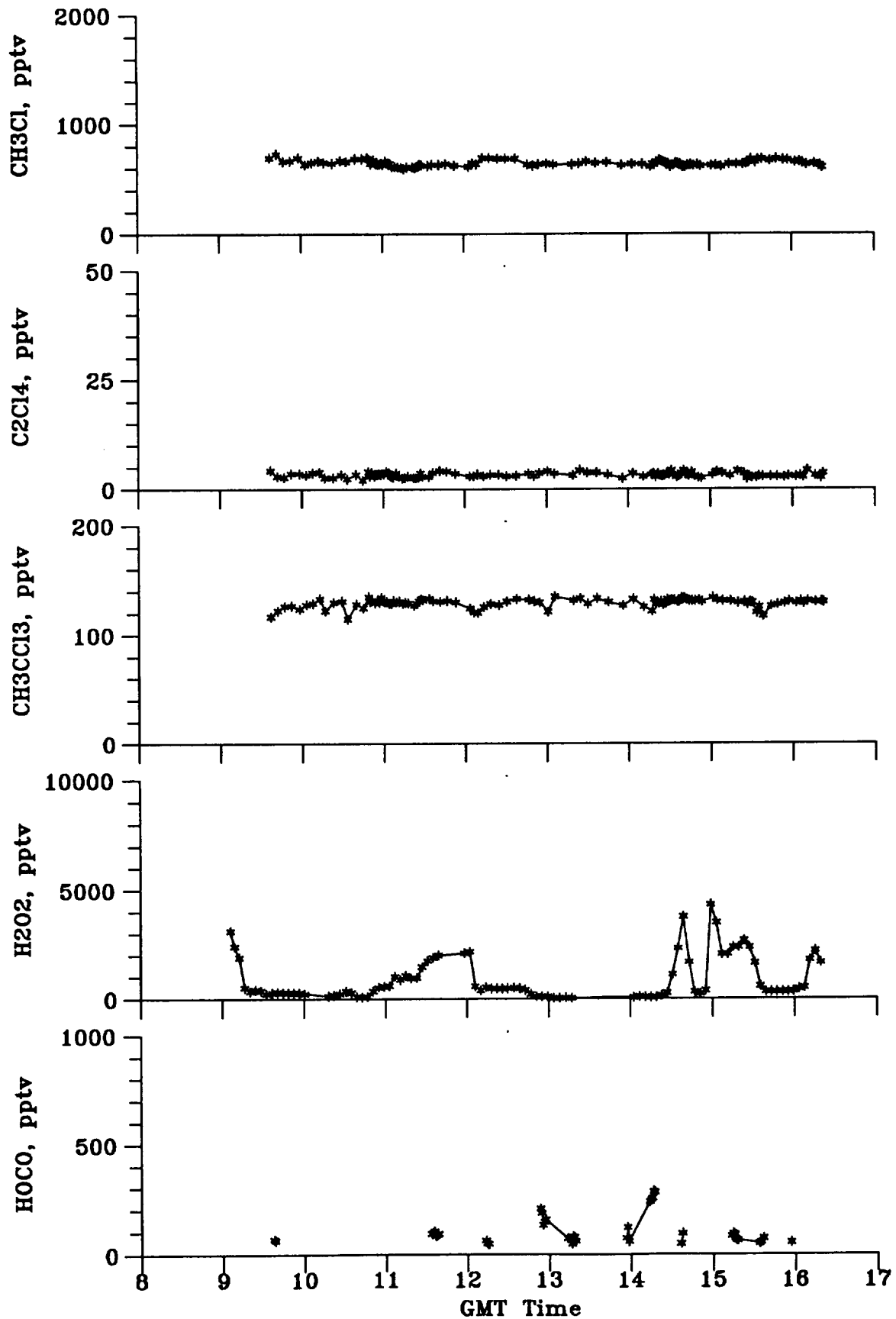


Figure A17.5

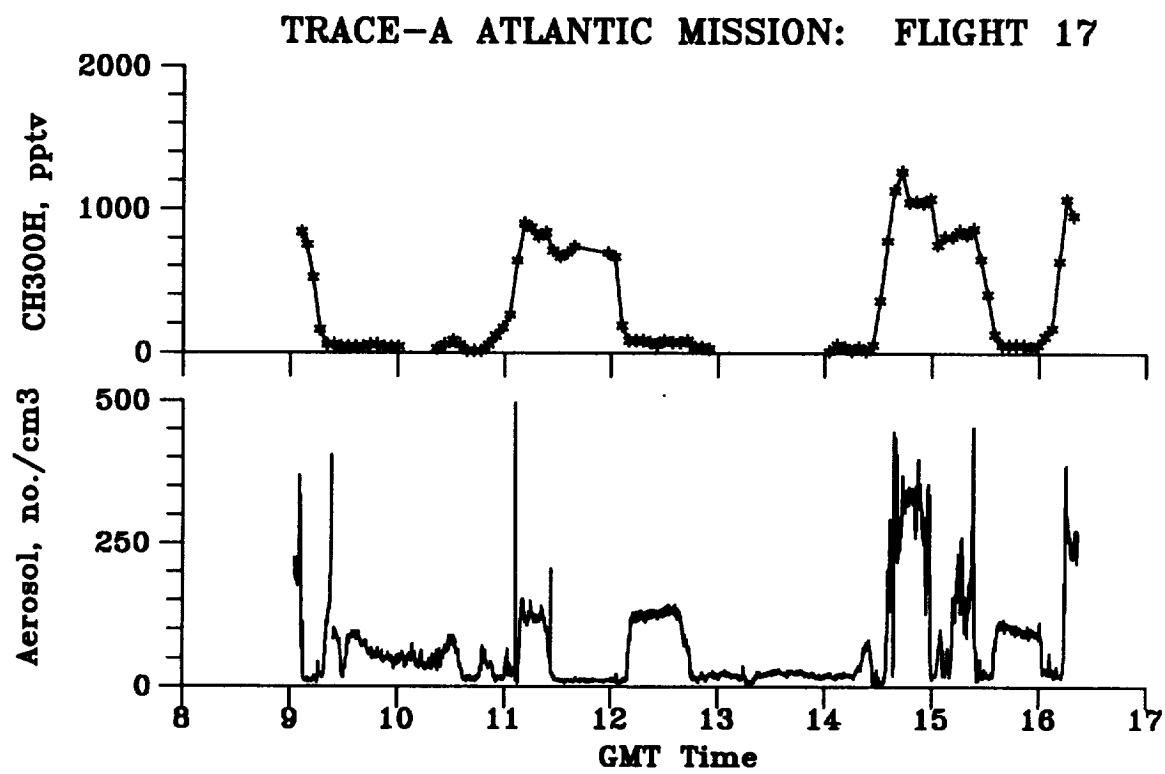
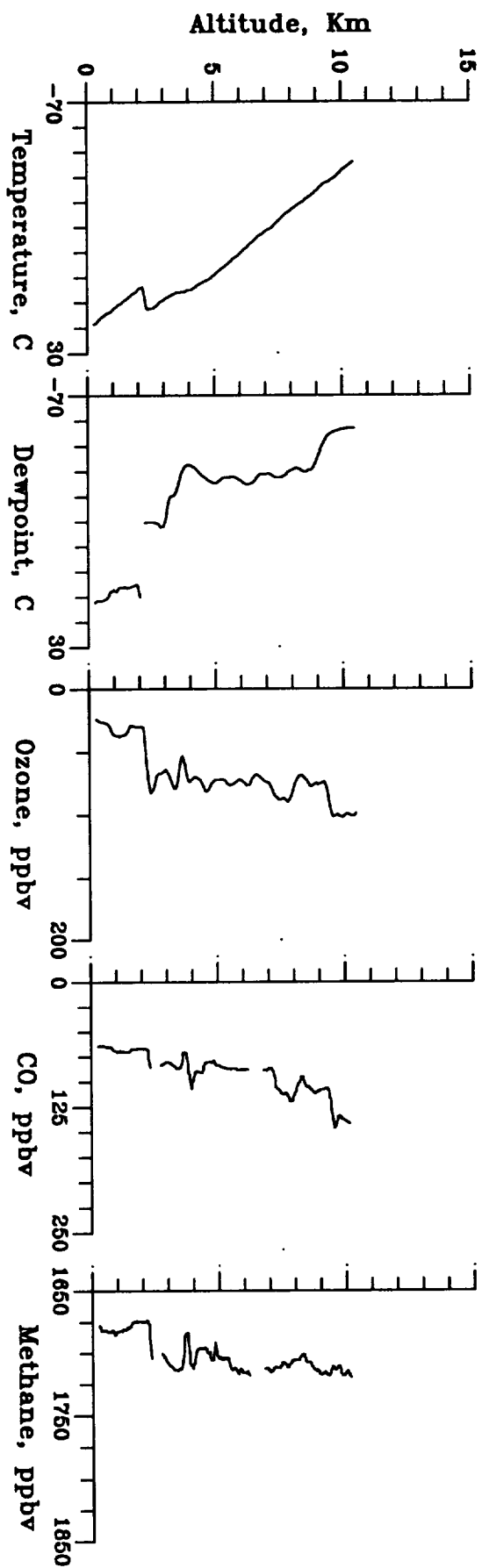
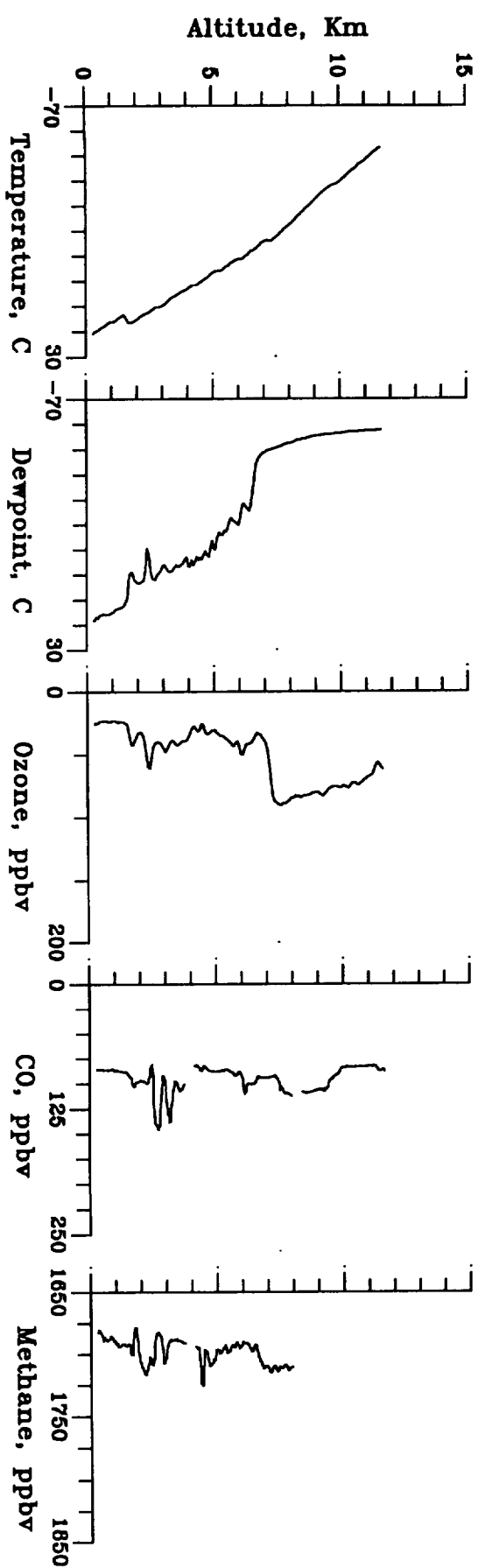


Figure A17.6

TRACE (A) ATLANTIC MISSION: FLIGHT 17 PROFILE AT 1100 GMT



TRACE (A) ATLANTIC MISSION: FLIGHT 17 PROFILE AT 1430 GMT



TRACE-A ATLANTIC MISSION: FLIGHT 18

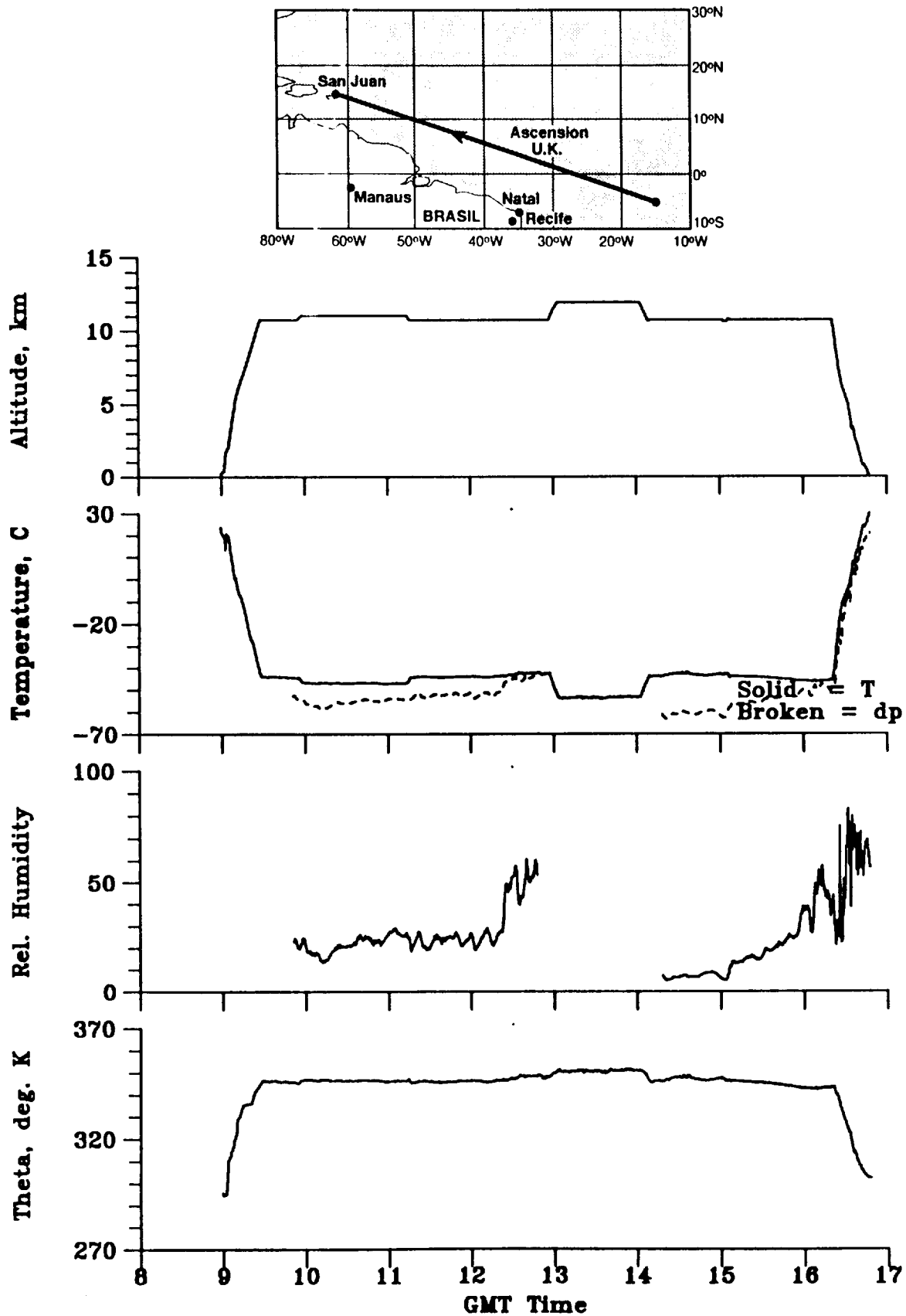


Figure A18.1

TRACE-A ATLANTIC MISSION: FLIGHT 18

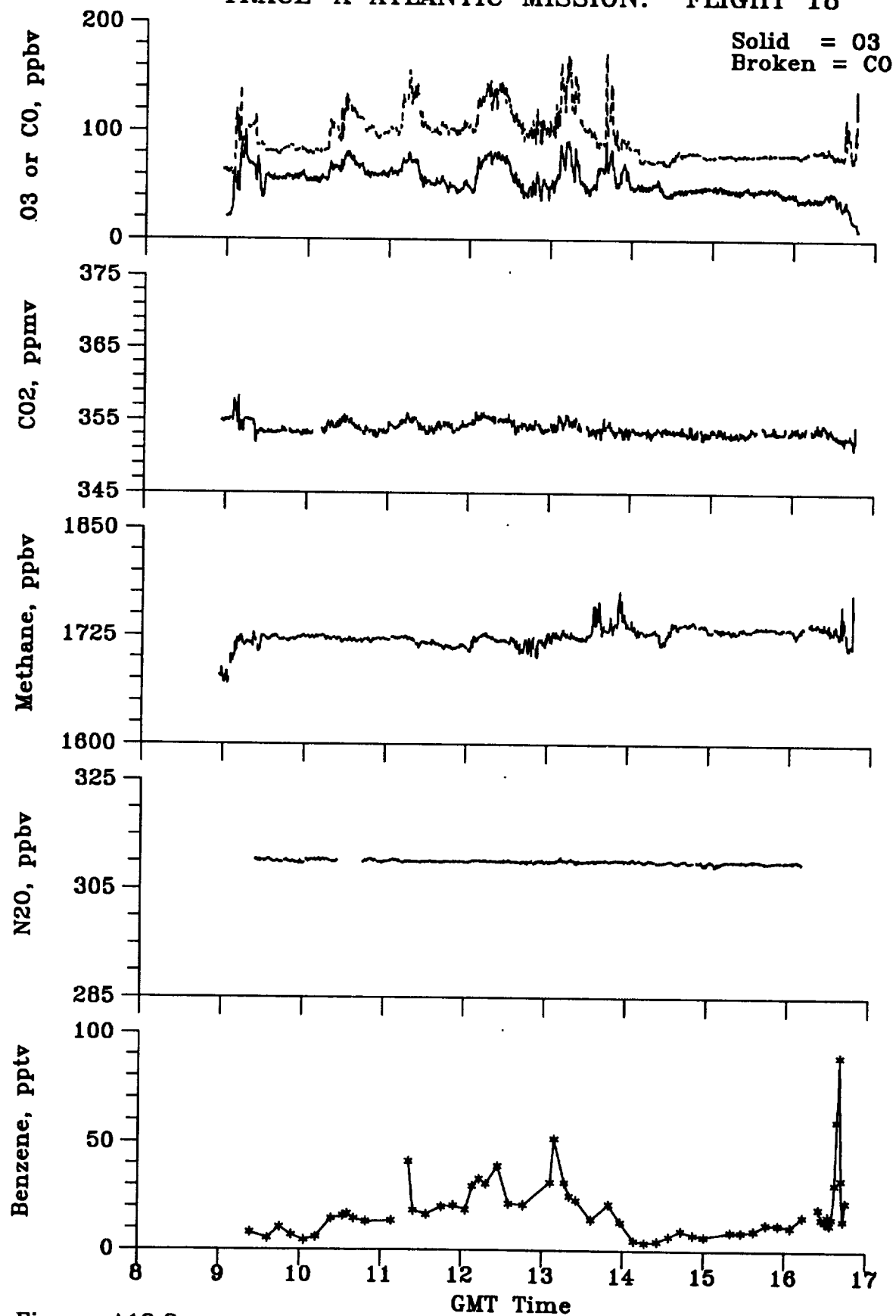


Figure A18.2

TRACE-A ATLANTIC MISSION: FLIGHT 18

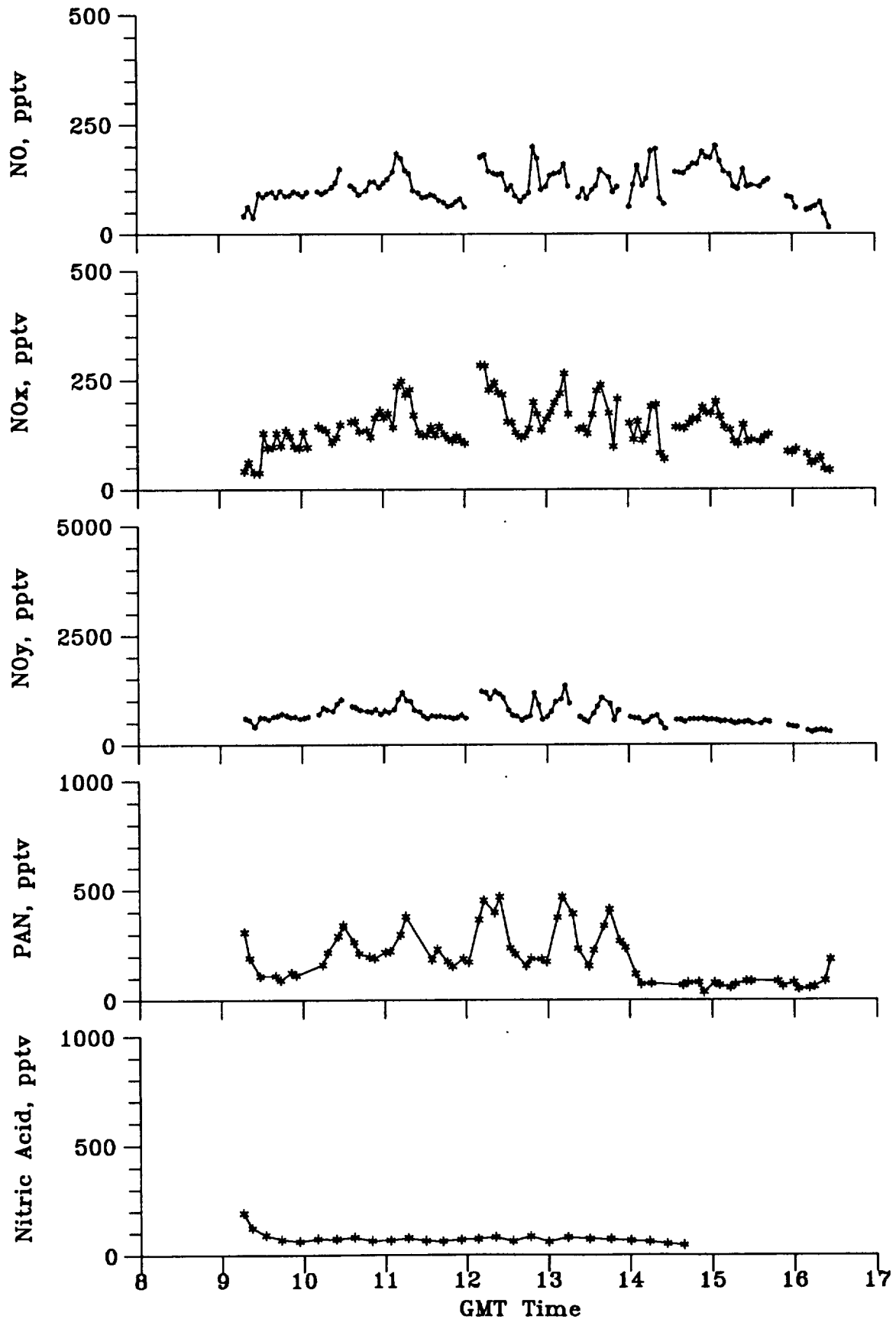


Figure A18.3

TRACE-A ATLANTIC MISSION: FLIGHT 18

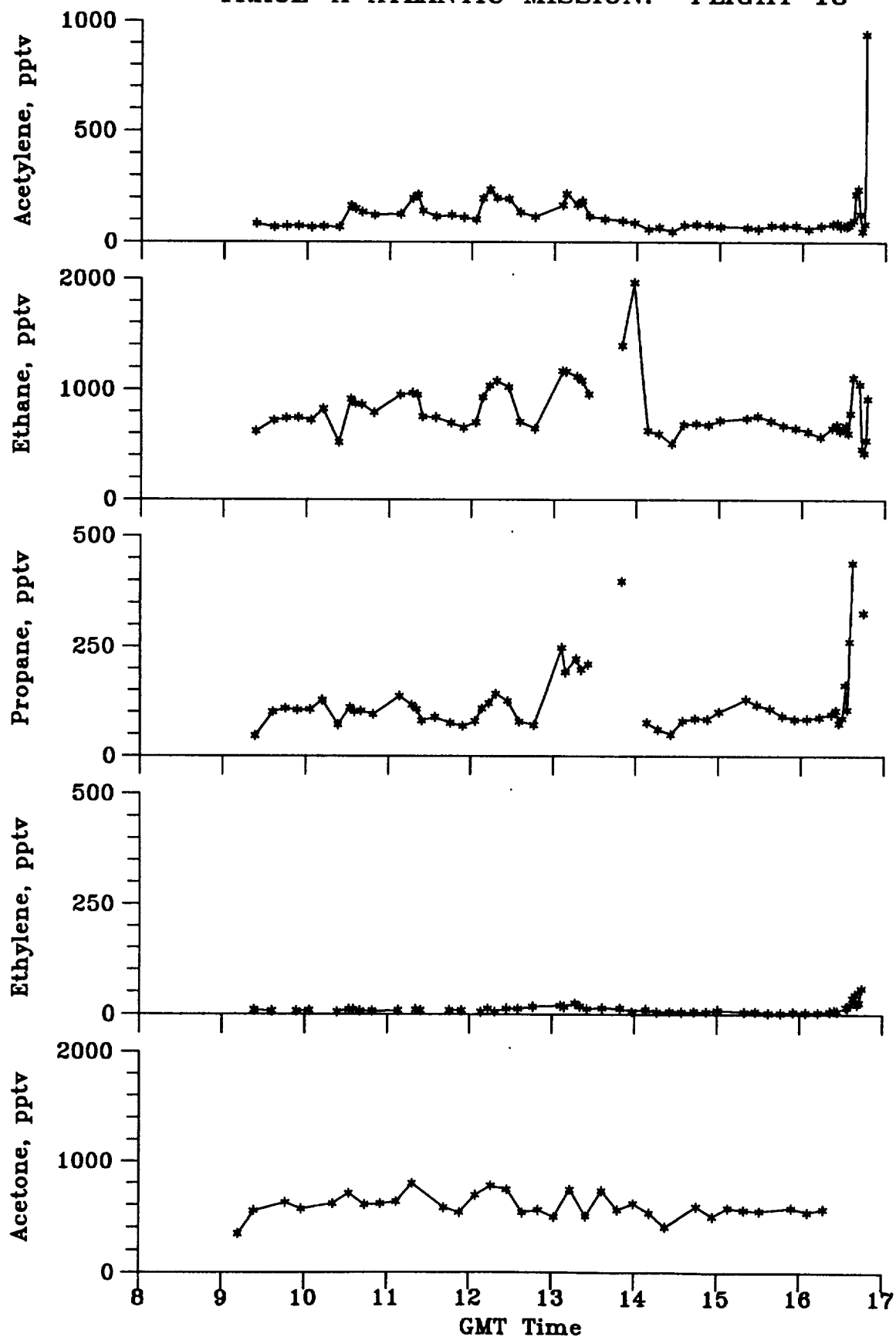


Figure A18.4

TRACE-A ATLANTIC MISSION: FLIGHT 18

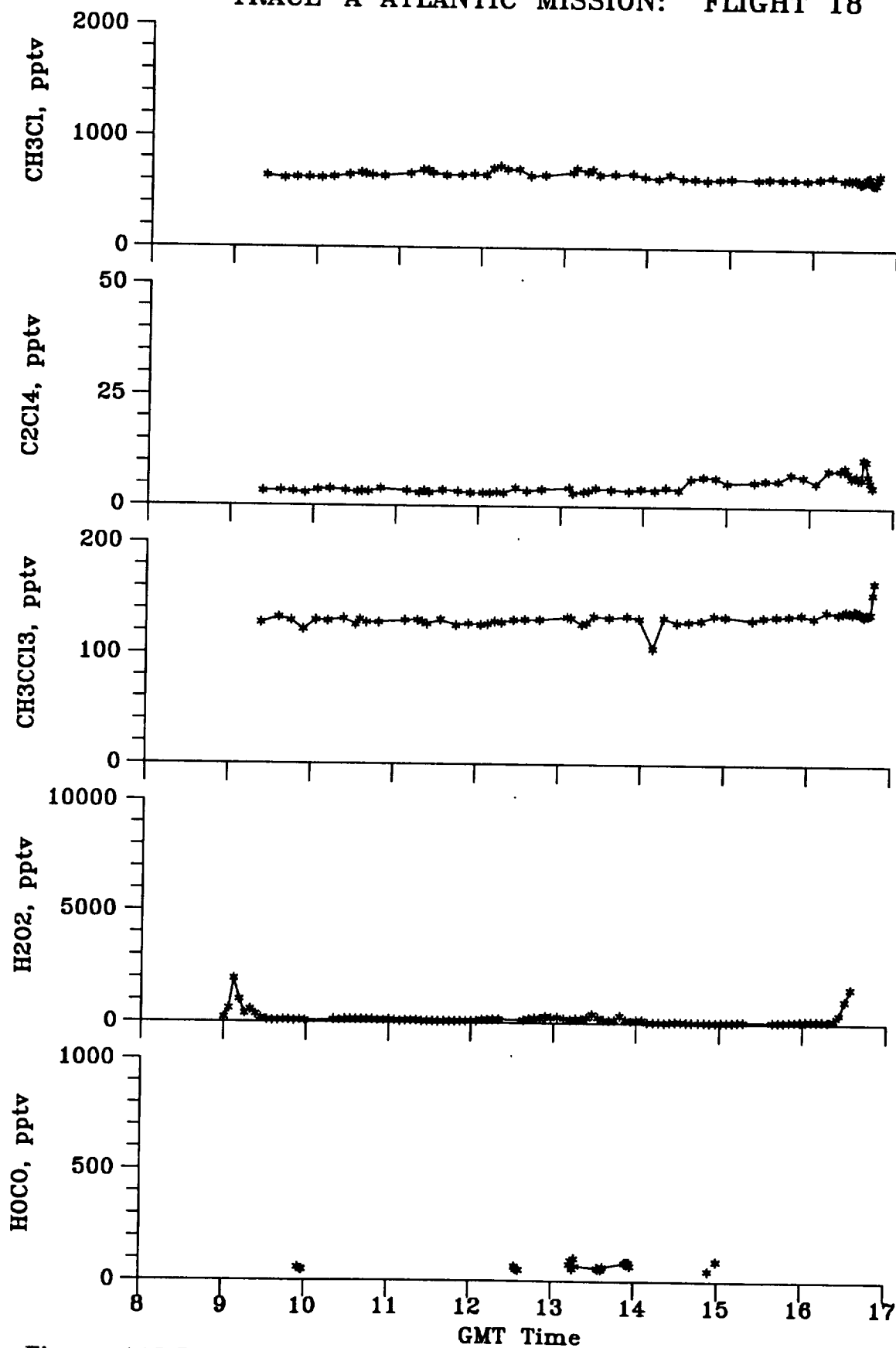


Figure A18.5

TRACE-A ATLANTIC MISSION: FLIGHT 18

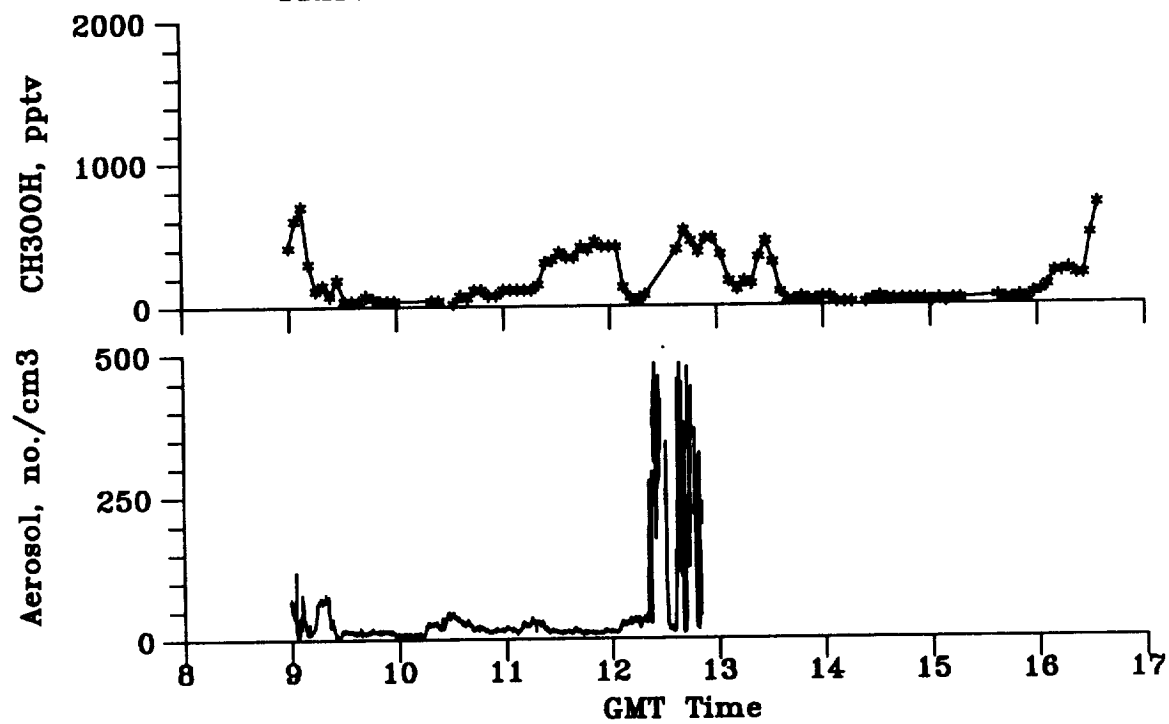
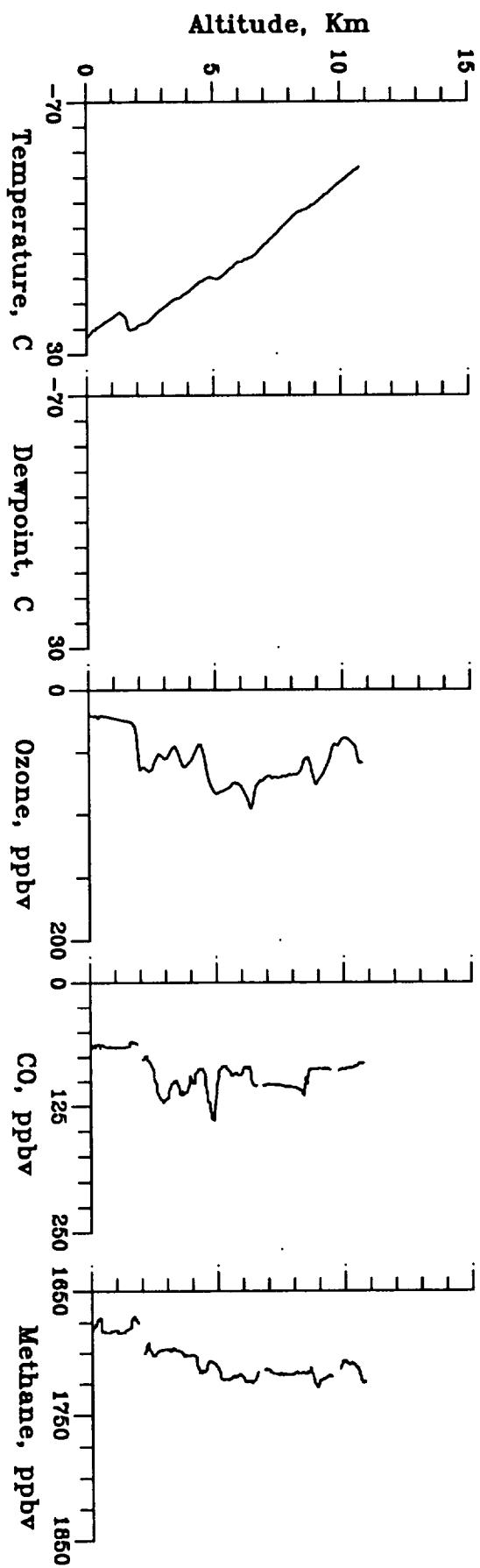


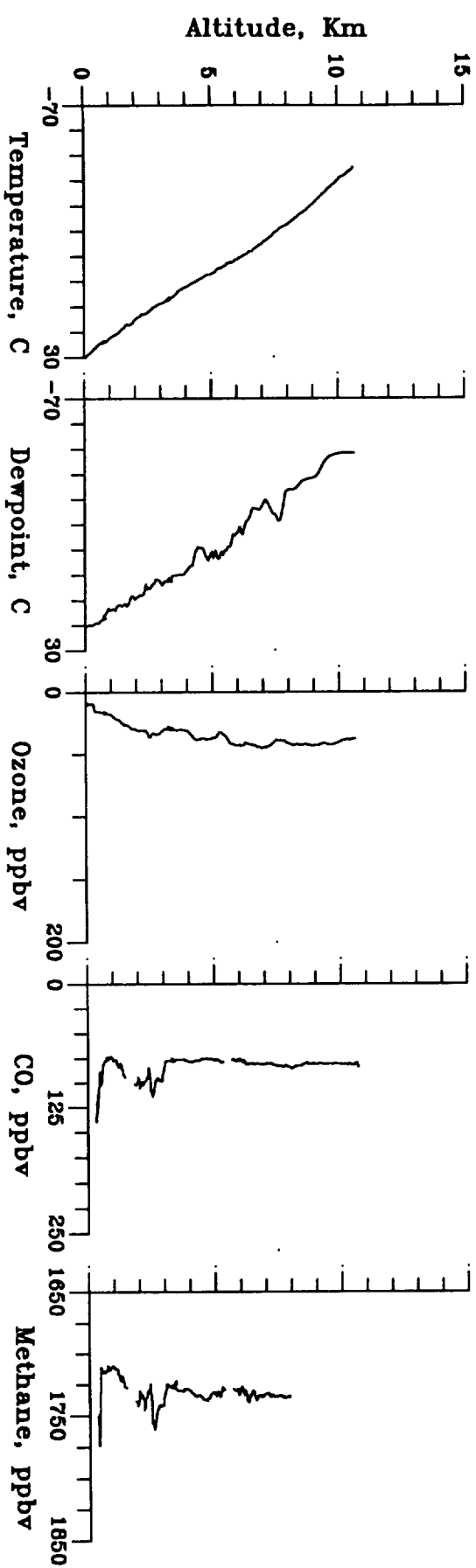
Figure A18.6

TRACE (A) ATLANTIC MISSION: FLIGHT 18 PROFILE AT 0915 GMT



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TRACE (A) ATLANTIC MISSION: FLIGHT 18 PROFILE AT 1630 GMT



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TRACE-A ATLANTIC MISSION: FLIGHT 19

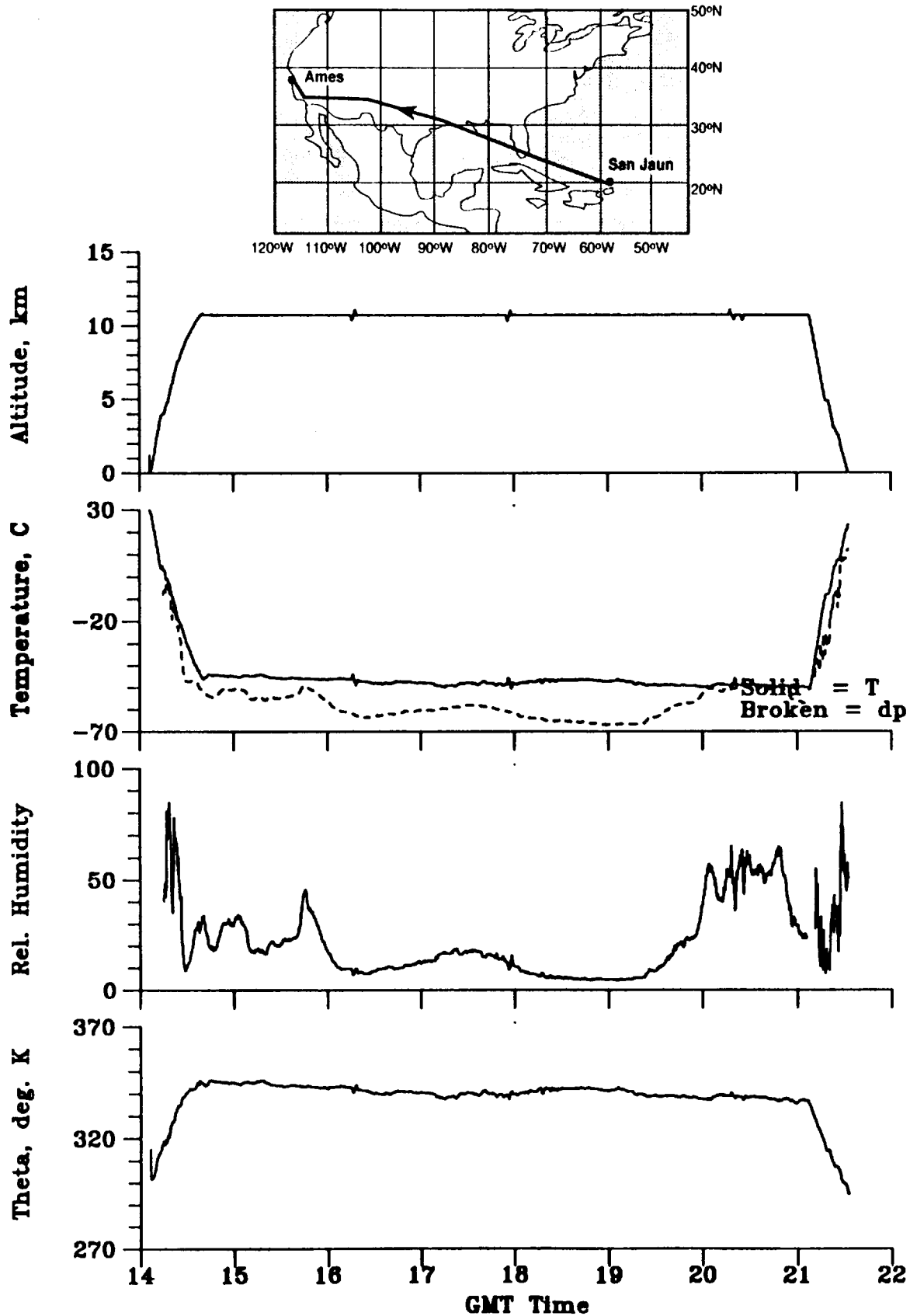


Figure A19.1

TRACE-A ATLANTIC MISSION: FLIGHT 19

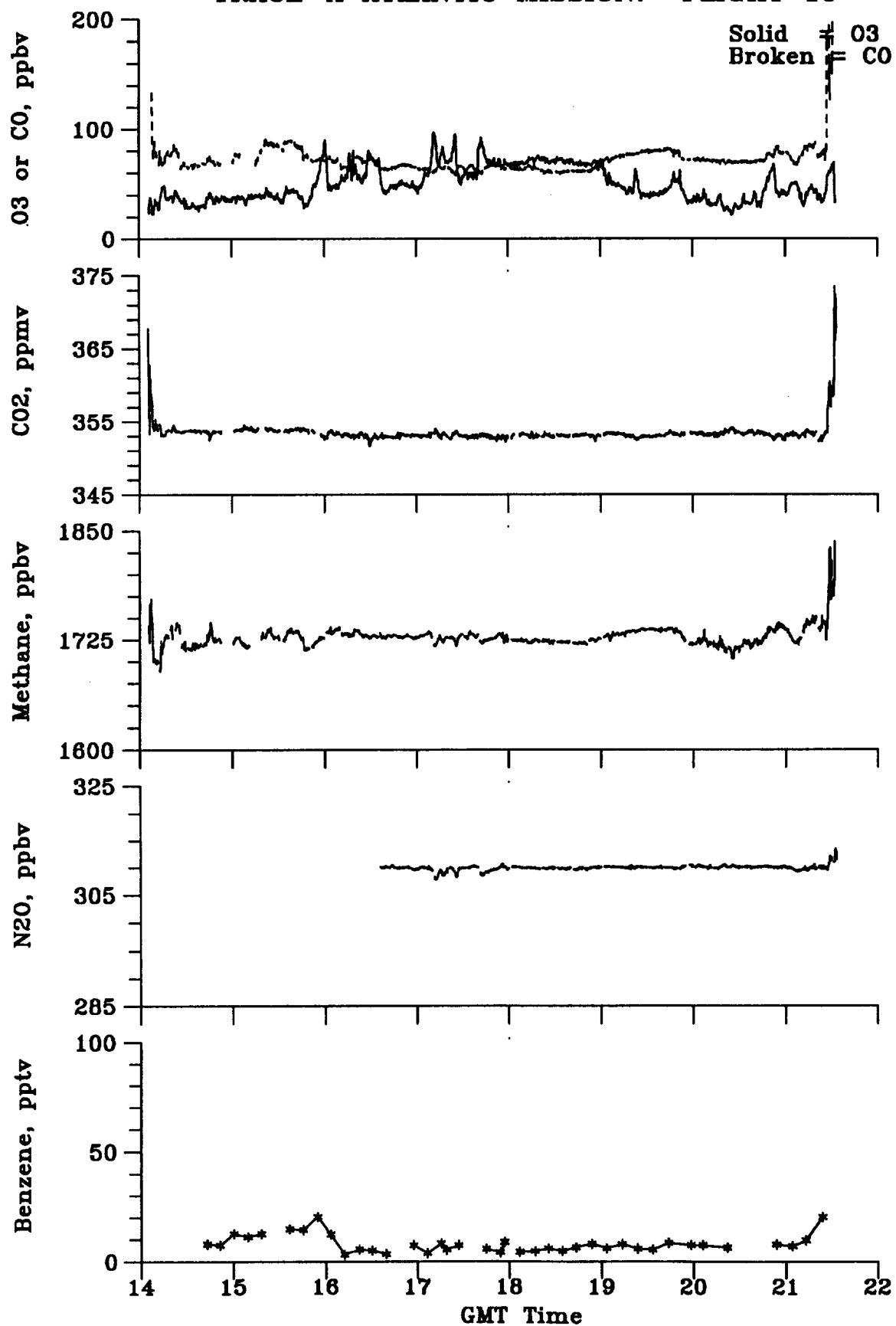


Figure A19.2

TRACE-A ATLANTIC MISSION: FLIGHT 19

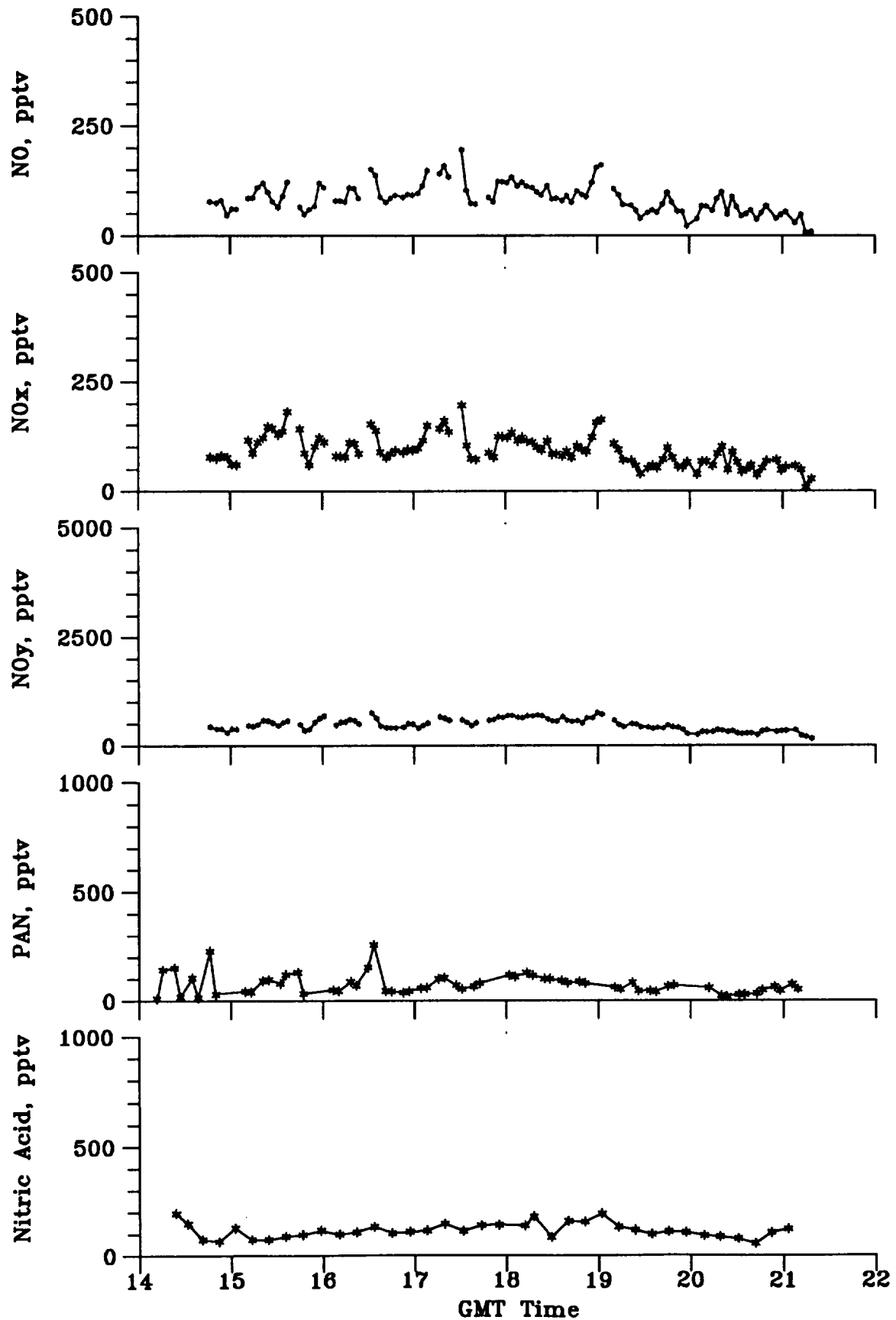


Figure A19.3

TRACE-A ATLANTIC MISSION: FLIGHT 19

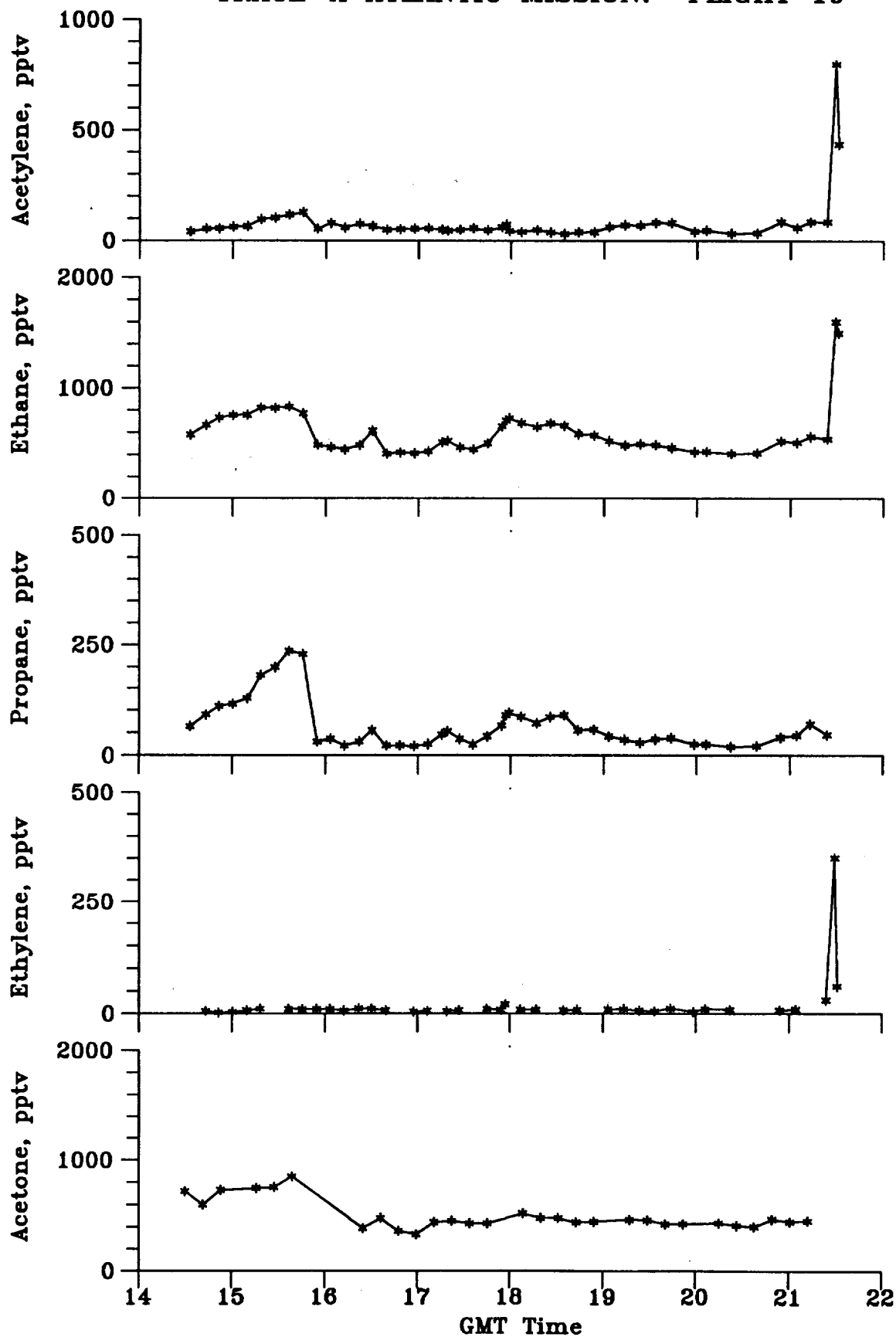


Figure A19.4

TRACE-A ATLANTIC MISSION: FLIGHT 19

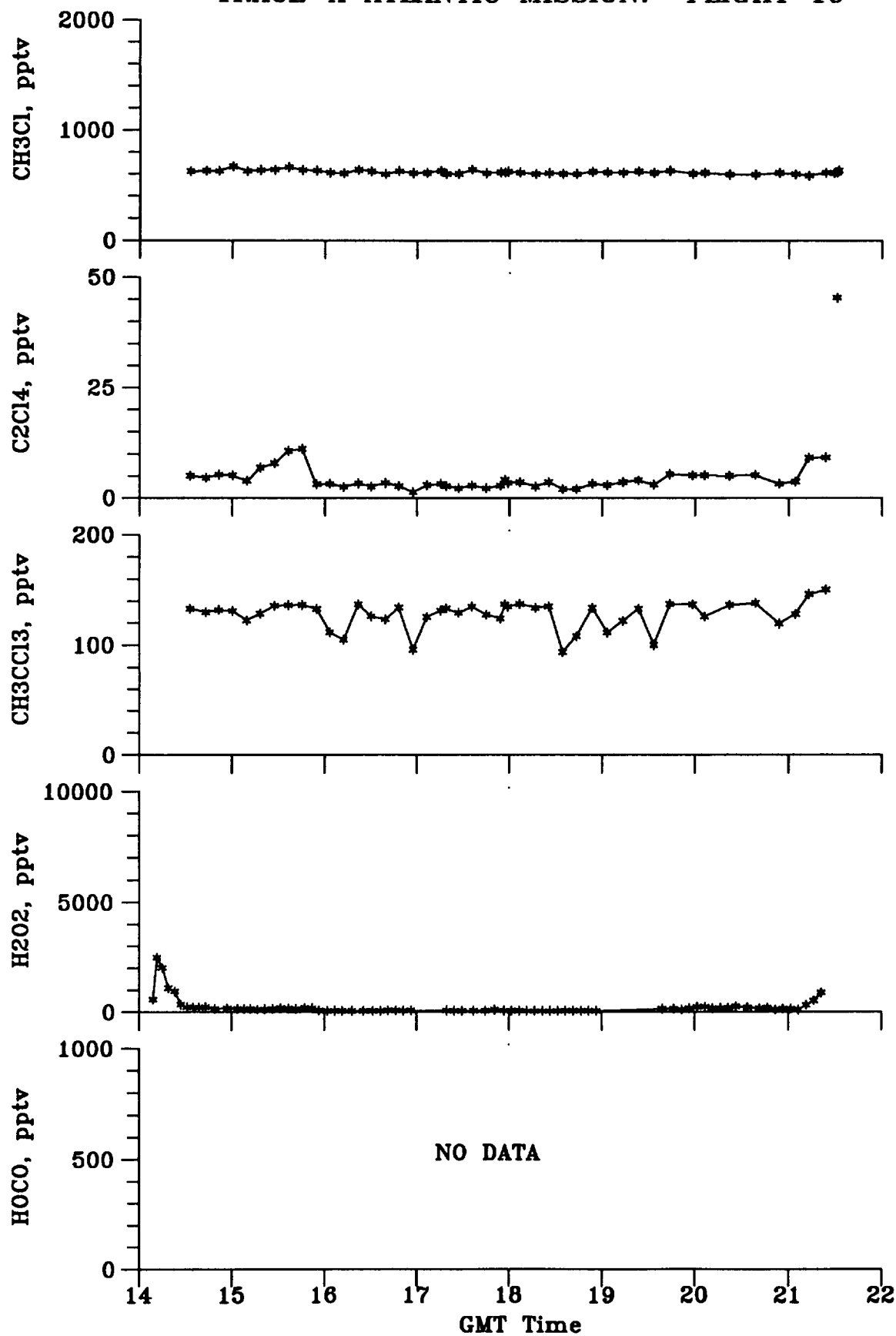


Figure A19.5

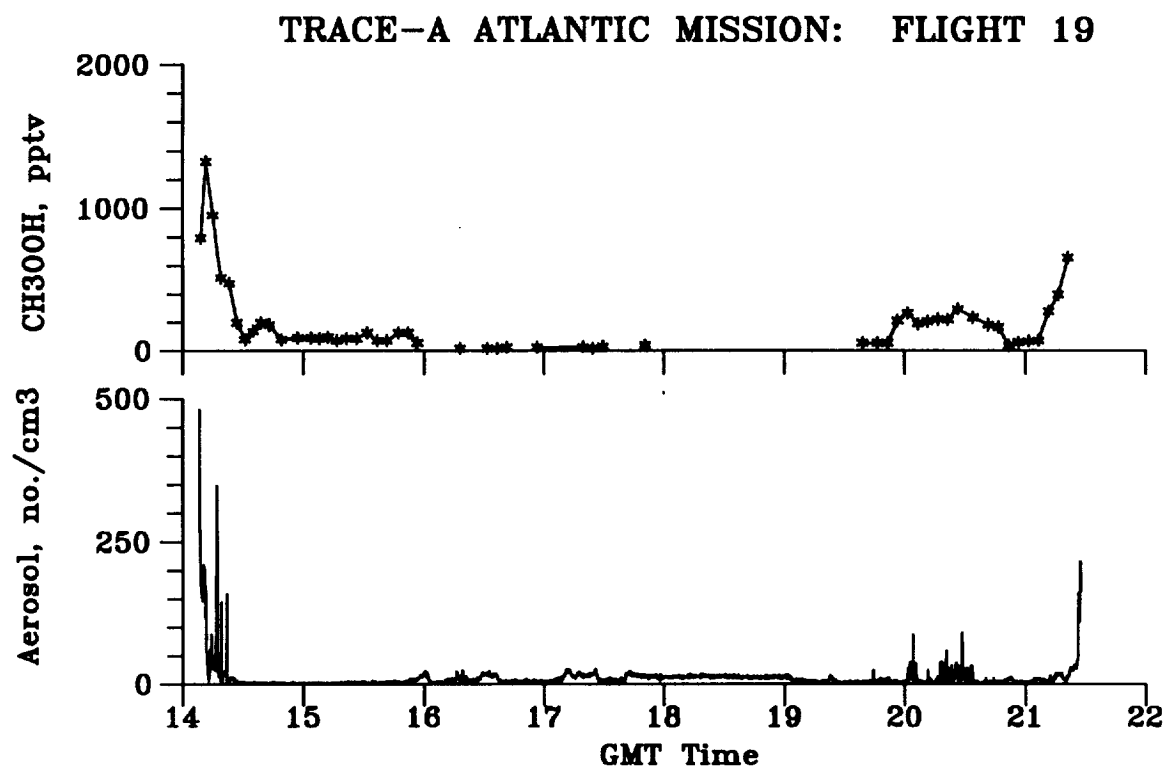
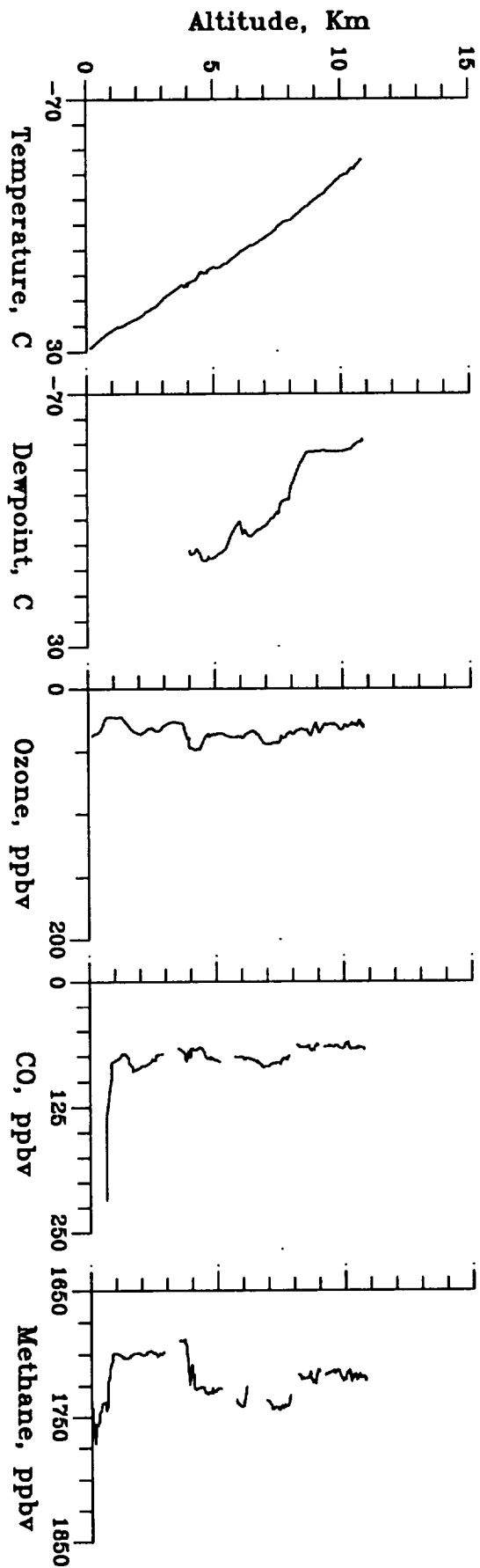


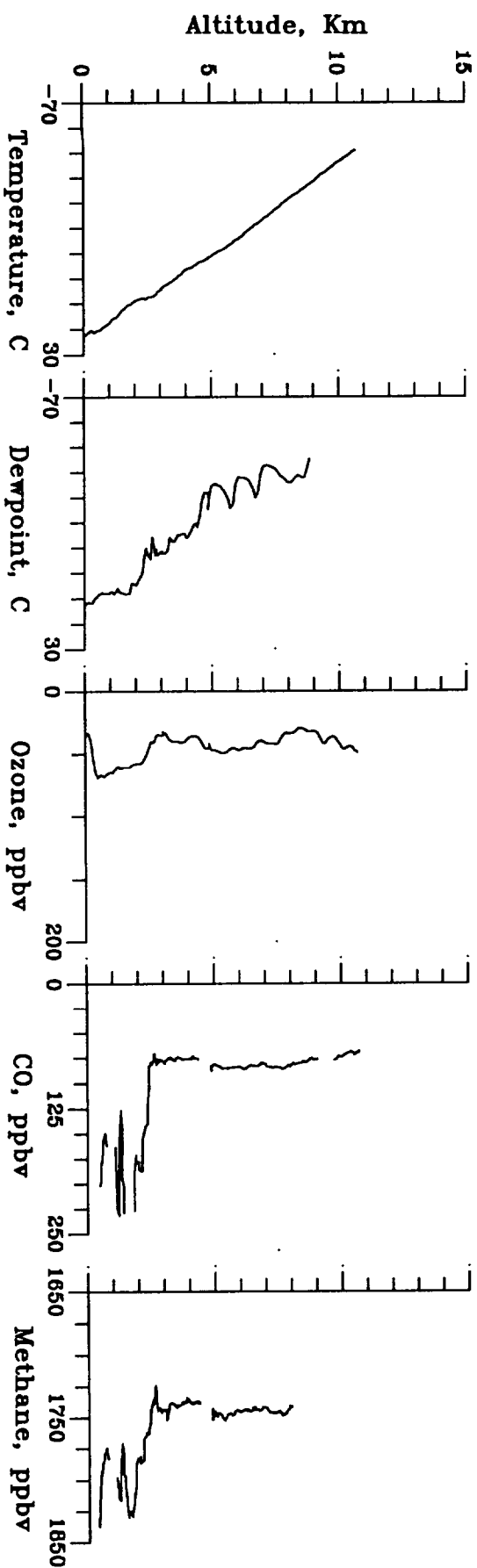
Figure A19.6

TRACE (A) ATLANTIC MISSION: FLIGHT 19 PROFILE AT 1430 GMT



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TRACE (A) ATLANTIC MISSION: FLIGHT 19 PROFILE AT 2115 GMT



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APPENDIX B: LANGLEY DAAC DATA ARCHIVE

System Description

The Langley Distributed Active Archive Center (DAAC), located at the NASA Langley Research Center in Hampton, Virginia, is responsible for archiving and distributing NASA science data in the areas of radiation budget, clouds, aerosols, and tropospheric chemistry. This DAAC will also archive some of the data sets which result from the EOS program and other elements of Mission to Planet Earth. The DAAC has developed an on-line computer system which allows the user to log on, search through the DAAC's data inventory, choose the desired data sets, and place an order. Data may be received either electronically (via FTP) or on media such as 4mm tape, 8mm tape, or CD-ROM (prepackaged data sets only).

Log On Procedures

1. Users with an X-Windows terminal (e.g., Motif) or a Sun Open Windows display system with access to Internet, may log onto the system by entering:

```
xhost + eosdis.larc.nasa.gov
(or: xhost + 192.107.191.17)
telnet eosdis.larc.nasa.gov
login name:  ims
password:  larcims
```

At the prompts, enter x for the X-Windows interface and then your display name (name of your workstation followed by ":0" or Internet address followed by ":0").

2. Users with access to NCSA Mosaic can use the following URL address:

```
http://eosdis.larc.nasa.gov/
```

3. Users without access to a terminal with an X-Windows display system but who have access to Internet may log onto the system by entering:

telnet eosdis.larc.nasa.gov

login name: ims

password: larcims

At the prompt, enter c for the character interface and then press return.

4. Users who cannot access the system or who have any questions concerning the Langley DAAC may contact:

Langley DAAC User and Data Services

Mail Stop 157B

NASA Langley Research Center

Hampton, VA 23681-0001

Phone: (804) 864-8656

FAX: (804) 864-8807

email: larc@eos.nasa.gov

DAAC Data Bases

1. ERBE (Earth Radiation Budget Experiment)--Data were collected from three satellites (ERBS, NOAA-9, NOAA-10) carrying two ERBE instruments (scanner, nonscanner). The objective is to measure global albedo, fluxes, and solar incidence.

2. ISCCP (International Satellite Cloud Climatology Project)--ISCCP focuses on the study of the distribution and variation of cloud radiative properties. The objective is to improve the understanding and modeling of the effects of clouds on climate and also to elucidate the role of clouds in the radiation balance and improve our knowledge of the long-term global hydrologic cycle.

3. SAGE (Stratospheric Aerosol and Gas Experiment)--SAGE I gathered data concerning the spatial distribution of stratospheric aerosols, ozone, and nitrogen dioxide on a global scale. The goals of SAGE II are to determine the spatial distributions of stratospheric aerosols, ozone, nitrogen dioxide, water vapor, and cloud occurrence by mapping vertical profiles and calculating monthly averages of each.
4. SRB (Surface Radiation Budget)--The SRB data sets were calculated using inputs from ISCCP and ERBE data. They are designed to give global daily and monthly averages of the albedo, irradiance, cloud properties, and meteorology.
5. FIRE (First ISCCP Regional Experiment)--This series of experiments includes aircraft, satellite, and surface-based measurements of cirrus and marine stratocumulus cloud parameters. The purpose of this program is to validate and improve ISCCP data products and cloud/radiation parameterizations used in general circulation models (GCMs).
6. GTE (Global Tropospheric Experiment)--Data were collected primarily from aircraft and ground-based instruments from a variety of areas such as the Amazon Rain Forest and the northern tundra and boreal forest. Many parameters were measured including O_3 , CH_4 , PAN, CO, NO, NO_2 , CO_2 , and aerosols.
7. MAPS (Measurement of Air Pollution from Satellites)--Data were collected during Space Shuttle flights in 1981, 1984, and 1994. The main pollutant measured was carbon monoxide (CO).
8. SAM II (Stratospheric Aerosol Measurement)--This instrument was flown on board the Nimbus-7 satellite and consisted of a one-spectral channel Sun photometer, centered at 1.0 μm , which viewed a small portion of the Sun through the Earth's atmosphere during spacecraft sunrise and sunset. The data obtained from this instrument were used to determine the vertical distribution of stratospheric aerosols in the polar regions of both hemispheres.

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